Vol. 1 NOVEMBER, 1922 No. 11

# JOURNAL

OF THE

# AMERICAN WELDING SOCIETY

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# American Welding Society

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# JOURNAL
## OF THE
# AMERICAN WELDING SOCIETY

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### TAKEN FROM JOURNAL OF THE WESTERN SOCIETY OF ENGINEERS

"The fall meeting of the American Welding Society was held in our rooms on October 2 to 5 inclusive. The meeting was well attended by representatives from all parts of the country and committee reports covering many different researchs being conducted by the Society in co-operation with Engineering Foundation and the National Research Council, were submitted. Some very excellent papers on Welding were presented".

### NATIONAL EXPOSITION OF POWER AND MECHANICAL ENGINEERING

The following invitation was received by the Society from the Chairman of the Advisory Committee of the above exposition. Free tickets may be obtained by writing or calling at the Secretary's office:

"On behalf of the Committee of the National Exposition of Power and Mechanical Engineering, an invitation is extended to each member of the Society of Welding Engineers to visit this exposition during December 7th to 13th at the Grand Central Palace, New York City, coming immediately after the annual meeting of the Association.

The exhibits will embrace every phase of the power field and will show the close relation of the engineer There will be models of considerable educational value which will trace the development of power production and tell the story from the mine to the power lines.

Experts from many branches will be present to give desired information upon the products exhibited and a program of motion pictures comprising studies in mechanical engineering and combustion will be shown in a special auditorium.

The Exposition is designed to be of the utmost service to engineers and it is the Committee's earnest wish that each member attend and take full advantage of the opportunities. The badge of the Society or the membership card is your pass to the Exposition."

### A. S. T. M. COMMITTEE ACTIVITIES IN CONNECTION WITH WELDING

*Committee* A-1 *on Steel*

At a meeting held in Detroit on October 6th, Mr. E. F. Kenney presented a report of progress as representative of the Committee on the Committee of the American Welding Society on Specifications for Steel to be Welded. The latter committee has made preliminary welding tests on steels of various carbon contents, from almost corbonless ingot iron to steel of 0.60 per cent carbon. Provision is being made for the maintenance of co-operative relations with the American Welding Society in the work of Committee A-1 on steels for welding purposes. Mr. F. N. Speller was appointed to serve with Mr. Kenney as a representative of Committee A-1 on the A. W. S. committee in place of Mr. H. L. Whittemore, who has been obliged to resign.

*Revision of Specifications for Plate for Forge Welding*

Committee A-1 on Steel is about to undertake a revision of the Tentative Specifications for Steel Plates for Forge Welding (A 78-21 T). Several revisions have been proposed by members of the committee. These have been referred to a special committee, appointed to undertake the revision. This committee, which is under the chairmanship of F. N. Speller, will keep in touch with what is being done on similar lines by the American Welding Society and the Boiler Code Committee of the American Society of Mechanical Engineers.

### READ THE JOURNAL

Letters coming in daily to the Society's office show that members do not

always read every page of the Journal. Important announcements of vital interest to members are often included in the Advertising Section. In fact it is only through reading this Section that members are enabled to keep abreast with latest developments in the way of equipment and supplies in the welding field.

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### BUREAU REPORTS

It is helpful sometime to see what others think about the work of the Research Department of the American Welding Society. We are quoting below extracts from correspondence which we have received.

*Extract from letter from Secretary Thos. Vickers, The British Cast Iron Research Association:*

"We have now received the copy of the August-September issue of your Journal which we consider is most valuable to our work, and we hope that in some way we can reciprocate your kindness".

"We repeat that we shall be only too pleased to send you the findings which are arrived at by our Committee in our investigation upon Welding Cast Iron, particularly that of Malleable Iron, as soon as the report is issued".

"We feel that we should like to have your Journal filed regularly in our Technical Bureau, and we shall be glad if you will inform us whether you can place us on preferential terms as members of the Society, so that we can receive the various publications issued by you. It appears to the writer that we come under Class B of your membership, but we await your decision upon this matter".

*Extract from letter of Mr. R. E. Wagner, Assistant Manufacturing Supt., General Electric Company, Pittsfield, Mass.:*

"Some grades of cast iron weld better than others, and it seems to me that the report should contain an analysis and photomicrographs of the grade of cast iron which is considered the most suitable. We have cases where the cast iron seems to crumble away from the heat of the arc. This iron also exhibits the same resistance to welding when an effort is made to weld it with gas. It appears, therefore, that there are some grades of cast iron that cannot possibly be welded by any means which we now employ."

"The report contains helpful information and puts in our records data that will assist us to make progress in solving this difficult problem".

*Extract from letter from Mr. O. H. Eschholz, Westinghouse Electric and Mfg. Co., East Pittsburgh, Pa.:*

"I wish to state that I have read the report of the Sub-Committee on Electric Arc Welding of Cast Iron in the August-September issue of the Journal with great interest and consider it one of the most important contributions to the welding literature".

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## SECTION ACTIVITIES

*Chicago*

The regular monthly meeting of the Chicago Section was scheduled for Friday, November 10th. The subject as announced was "Applications of the Oxy-Acetylene Process in the Chicago District".

*Northern New York*

A meeting of the Section was scheduled for October 24th, with the general subject, "Practical Experience with Arc Welding", by Messrs. J. McAllister, S. R. Stockholm and J. A. Wilson.

Mr. McAllister, Gen. Foreman West Albany Shops, N. Y. C. R. R., is the originator of the studding process as applied to the Arc Welding of Cast Iron. Mr. Stockholm, Proprietor Troy Electric Welding Co., has had much practical experience with Arc Welding. Mr. Wilson, Foreman, General Electric Welding School at Schenectady, has had much experience in using automatic welding machines and in the training of operators.

*Philadelphia*

The next meeting of the Philadelphia section will be held at the Engineers Club, November 20th.

*Boston*

The following is taken from the program of meetings for the Boston Section:

*November* 17, 1922. At Massachusetts Institute of Technology. Practical Demonstration of Thermit Welding (with a discourse on its applications, its advantages, and an open discussion on its drawbacks, if any).

*December* 15, 1922 At Massachusetts Institute of Technology. Moving Pictures

on the manufacturing of gases. (Open Forum at the conclusion of the illustration).

*January* 19, 1923. At the River Works Plant of the General Electric Company, West Lynn. Mass.

*From* 3:00 *P. M. to* 4:00 *P. M.* A demonstration of Hand Welding, Semi-Automatic Arc Welding, Automatic Welding, Resistance Welding, and Resistance Welding with Mechanical Interrupter. Also practical Gas Welding.

*From* 4:00 *P. M. to* 6:00 *P. M.* Moving Pictures—"Welding as Applied to Ship Construction."

*From* 6:00 *P. M., to* 7:30 *P. M.* Buffet Lunch.

*From* 7:30 *P. M. to* 8:00 *P. M.* Mr. Noble of the Northern New York Section of the American Welding Society, will speak on Automatic Arc Welding.

*From* 8:00 *P. M. to* 10:00 *P. M.* Mr. C. A. McCune, President of the American Welding Society, will give a talk on the manufacture of welding wire, and have Moving Pictures to show, which will take us from mining the ore to putting the wire on reels as used in Welding Departments.

In connection with the meeting on January 19, it is planned to have 100 members present from the local section of the A. S. M. E. and a like number of students from the Massachusetts Institute of Technology.

*Metropolitan*

A meeting of the Metropolitan Section was held in the Engineering Societies Building on Monday afternoon, November 13th, at which time two papers were presented. One of these papers dealt on "Possibilities of Welded Pipe in High Pressure Gas Distribution," by G. O. Carter, Consulting Engineer, Linde Air Products Company, and "Production Welding in the Sheet Metal Shop," by Mr. J. W. Owens, Welding Aide and Assistant Shop Superintendent, Norfolk Navy Yard.

*Los Angeles*

A meeting of the Los Angeles Section was scheduled for November 10th, at which time a paper was to be delivered by Mr. R. L. Hemingway, Safety Engineer of the State Industrial Accident Commission on Welded Pressure Vessels. The meeting was to be proceeded by a banquet at the City Club.

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## NEW MEMBERS FOR THE MONTHS OF JULY, AUGUST AND SEPTEMBER

| | Class |
|---|---|
| *Boston* | |
| Court W. Babcock, Westinghouse Elec. & Mfg. Co., ..... | B |
| F. A. Barbey, N. E. Rep. Commercial Acetylene Co. of N. Y. | C |
| Alfred Olsen, Boiler Maker, 382 Myrtle St., Manchester, N. H., | C |
| John A. Robinson, Acetylene welder, Union Welding Co. ..... | C |
| Herbert A. Woofter, E. E. Thomson Electric Welding Co. ..... | B |
| *Chicago* | |
| K. R. Hare, District Mgr., Transportation Engr. Corp. ..... | B |
| Edward Wray, Pub. Railway Purchases & Stores, 9 So. Clinton, Chicago, ..... | B |
| *Cleveland* | |
| J. C. Upton, Oxweld Acetylene Co. | B |
| *Los Angeles* | |
| D. E. James, Washington St. Yards P. E. Ry. ..... | D |
| *New York* | |
| Fulton L. Dobson, M. M. Meadow Shops, Penna. R. R. ..... | C |
| F. L. Rogers, Sales Rep. Oxweld Acetylene Co., Newark, N. J. | B |
| James N. Walker, East Dept., Sales Engr. Oxweld Acetylene Co., Newark, N. J. ..... | B |
| *Northern New York* | |
| Martin Friedman, Elec. Welder Martin Machine & Elec. Welding Co., Schenectady, N. Y. .. | D |
| Wm. LeRoy Warner, Engr. General Elec. Co., Schenectady, N. Y. ..... | D |
| *Philadelphia* | |
| John Emrick, Oxy-Acetylene | |

Welder, Penna. R. R. Enola Shops, Enola, Pa. ..... D

James B. Seddon, Elec Welder Phila. Navy Yard ..... D

*San Francisco*

E. L. Curtis, Mfg. Welder, Curtis & Geer Co. ..... B

A. V. Thompson, Sales Agent, General Electric Co. ..... C

*Pittsburgh*

Raymond J. Davis, Acetylene Welder, Dennison, Ohio ..... D

*Not in Sections*

Frank W. Steere, Vice-Pres., Steere Engr. Co., Detroit Mich. B

George M. Jones, Proprietor, C. M. Jones, Elec. Repair Shop, Scranton, Pa. ..... C

Oscar Evans, Electric Welder Russelton, Pa. ..... D

## EMPLOYMENT SERVICE BULLETIN

To meet the demand of its members, the American Welding Society maintains an Employment Service Bulletin. This service is particularly needed in the present business readjustment. The bulletin is divided into two sections—POSITIONS VACANT and SERVICES AVAILABLE. No charge will be made either to the available engineer, foreman or welder, or to the organization seeking welding talent. The number of opportunities for employment of which the Society has knowledge does not at present equal the number of men whose services are available. The cooperation of members of the Society, industrial establishments and others needing the services of men trained in the various branches of welding is earnestly desired. The fact that an applicant for a particular position reads the Journal of the American Welding Society shows an honest effort on his part to keep abreast of the latest advancements in his chosen field. The location, necessary, qualifications for each position and the approximate salary, if possible, should be stated in each case.

Opportunities.—The Society is glad to learn of desirable opportunities from responsible sources, announcements of which will be published without charge in the bulletin.

Services Available.—Under this heading brief announcements (not more than seventy-five words in length) will be published without charge to members. Announcements will not be repeated except upon request received after an interval of three months; during this period, names and records will remain in the office reference files.

Note.—Copy for publication in the BULLETIN should reach the Society's Office not later than the Thirtieth of the month if publication in the following issue is desired. *ALL REPLIES should be Addressed to the Number Indicated in Each Case and Mailed to Society Headquarters.*

## SERVICES AVAILABLE

A-15—Experienced Electric Welder desires position. Have had six years' experience welding in ship yards and on boiler and repair work. Can furnish references. Last position with Brooklyn Navy Yard.

# ELECTRIC ARC WELDING OF CAST IRON

W. H. NAMACK,

*Chairman, Sub-Committee, Northern New York Section,*
*On Arc Welding of Cast Iron*

## Part II.

As pointed out in Part I of the paper on the above subject, appearing in the August-September, 1922 issue of the Journal the work of the Northern New York section was divided into two parts. The first consisted in drawing up a summary of the present state of the art in regard to the welding of cast iron and included such authentic information as the Committe could collect. There were a number of points, however, on which further data was needed. A program of investigations was accordingly carried out by the Committee on some of these points. There are still a number that remain unsolved and the Committee recommends that the American Bureau of Welding, through its Electric Arc Welding Committee give these points careful consideration with the view of assigning them to appropriate localities or laboratories for completion.

The problem of welding cast iron by means of the electric arc is not a single definite problem which might be solved easily by making a few tests. In fact the Committe has discussed it from every point of view and has found not one, but many difficulties which confront the investigator from the start. The variables are many and the control of these variables is in some cases most difficult. The personal element is probably the greatest variable, but it can be made less dominating by proper selection in carrying out a series of tests although it is yet to be controlled in the practical application of arc welding. It is not the purpose of the Committee to here attempt a full discussion of the different problems involved, but rather to enumerate the various points which appear most important and which offer fields for investigation. The desideratum is a method which shall insure satisfactory machineability, low porosity, and a strength approaching that of the base material.

### PROPOSED PROGRAM OF RESEARCH

1. Determination of the proper current to get the best adhesion between filler and base metals.
2. Determination of the proper electrode to get the best adhesion.
3. Prevention of the hard zone at the junction of the filler and base metals.
4. Prevention of free carbon and slag in the weld metal.
5. Study of straight versus reversed polarity.

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*This report has been prepared under the auspices of the American Bureau of Welding. Presented at the Fall Meeting of the American Welding Society, Chicago, Oct. 1922.

6. High versus low temperature welding.
7. Prevention of the closing of the "Vs" opening between plates while welding.
8. Multiple interlocking layers versus a single spirally deposited layer.
9. Single versus double V groove.
10. Method of determining the grade of the cast iron.

In the course of its investigations, the Committee has considered the following points:—

(1) Preparation of the parts to be welded.
(2) Prevention of slag inclusions in the weld metal deposited.
(3) Suitable values of current for the size of electrode employed.
(4) Method of deposition of the filler metal and its effect on the strength and hardness of the weld.
(5) Reversed polarity versus straight polarity.
(6) Effect of long versus short arc.
(7) Effect of speed of welding on the softness of the weld.
(8) The hard zone and its removal.
(9) The relative weldability of various grades of cast iron.
(Tests were made on two typical grades at present in wide use)
(10) Tests of electrodes with a view to ascertaining the most suitable materials, construction and characteristics for use in welding various grades of cast iron.

The above outline of the Committee's deliberations may seem to the reader as inconsistent with the Proposed Program of Research, but as already stated in the introduction the Committee could not solve all points by one series of tests, and therefore tests were made in accordance with a program based on the results of the Committee's deliberations. It was thought that the conclusions which could be drawn from such tests might clear up some of the points mentioned in the *Proposed Program of Research.*

*Preparation*

The Committee decided that in the preparation of the parts to be welded the single V is better than the double V because in actual service the double V is in most cases, practically impossible. A single V was used in all of the Committee Tests.

*Slag Inclusions*

It is usually agreed that gray cast iron is the most uncertain grade to weld. The difficulty seems to be due largely to the free carbon present which is called "kish." When welding with bare electrodes this "kish" causes a dark deposit to form on the weld metal. Chemical analysis indicates this deposit to be iron silicate or slag, which often times causes a defective weld by lodging in the weld metal forming what are called "slag inclusions." Two methods suggested to remove this "kish" seemed suitable to the Committee, viz., first, the surface to be welded may be subjected to a slight preliminary melting with the carbon arc, second, a high current value in the

welding process may give the desired results. Mr. C. J. Holslag of the Electric Arc Cutting and Welding Company, on page 41 of the March 1922 issue of the Journal of the American Welding Society, states that going over a cast iron surface with a 600 ampere carbon arc renders the subsequent welding process much easier than welding directly on an untreated cast iron surface.

The practicability of using a high heat in the welding operation would depend upon the thickness of the parts to be welded and the skill of the operator. It would seem that the localization of heat has a tendency to create an annealing effect and the Committe believes that the data incorporated in the test results will tend to show that this proposition to use a high heat value in the welding operation has some worth.

*Current Values*

For cast iron welding by the metallic arc process, the following current values have been found to produce the best results with average welding ability:

| SIZE OF METAL ELECTRODE | CURRENT |
|---|---|
| 1/8" Electrode (on plates up to 3/16" thickness) | up to 125 amperes |
| 5/32" Electrode | 135-175 amperes (depending on the thickness of the plate). |

*Method of Deposition*

The usual method of depositing the weld metal is to apply it in layers or beads lengthwise of the weld. In this way a series of interlocking layers is formed which, if brushed vigorously after each layer is deposited, should give a clean weld. Furthermore the heat can be kept low and consequently the expansion will be small. The deposition of metal by means of a single spiral layer was however, strongly advocated and this latter method was employed in performing most of the Committe tests.

Some members of the Committe advocated using reversed polarity to reduce the heating effect of the arc on the base metal but this suggestion was not adopted in the tests. Probably for some electrodes and for some kinds of cast iron, better results can be obtained with reversed polarity.

*Length of Arc*

The Committe decided that an arc length not over 1/8" would give a deeper and more uniform penetration and would insure a stronger weld. In order to test this suggestion samples of long and short arc deposition on both steel and cast iron were given to Mr. T. S. Fuller of the General Electric Research Laboratory to analyze. The results are given in Fig. 1 and described below.

*The Nitrogen Theory*

Mr. Fuller investigated the three zones, shown in the photograph, Fig. 1, by means of photomicrographs. Sections taken at the top of the bead, at the junction of the filler and base metals, and in the lower dark zone showed traces of nitrogen in the form of dark needles. This nitrogen or "nitride" as it is called, was present in both the steel and cast iron welds. The presence of carbon together with the "nitride" is the cause of the hardening effect. The hard zone in the steel weld is soft enough to be machineable and gives no trouble. The hard zone in the cast iron was very hard and not machineable.

The four photographs in Fig. 1 show the depth of penetration and hard zones: for two gray cast iron welds (No. 1 & 3) and two steel welds (No. 2 & 4).

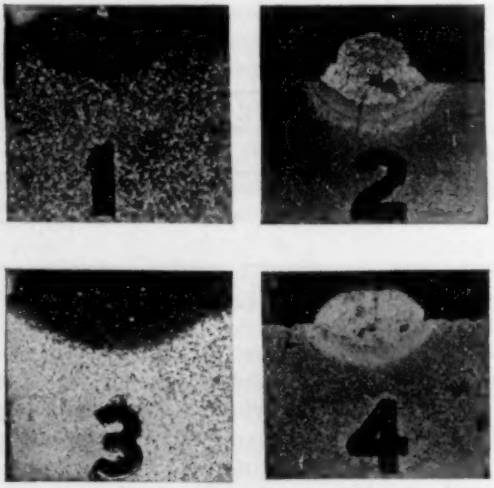



Fig. 1. Illustration showing depth of penetration with long and short arcs.

The following remarks on each of the four photographs should be studied.

1. *Gray Cast Iron. Short Arc with bare electrode.* Note that the filler metal is amalgamated nearly to the bottom of the black area and that the black area is somewhat more shallow than in the case of photograph number 3.

3. *Gray Cast Iron. Long Arc with bare electrode.* The difference between "heat penetration" and "weld penetration" can be very clearly distinguished in this picture. There are two hard zones here: one at the bottom of the filler layer and the other at the lower edge of the dark area.

2. *Steel with bead from bare electrode deposited with short arc.* The hard zones are present but are not as troublesome as in the case

of the cast iron, due to the fact that there is not as much carbon present.

4. *Steel with bead deposited from bare electrode with long arc.* The different zones can be clearly distinguished here.

*Speed of Welding vs Softness*

As the result of a series of tests the Committee concluded that the speed of welding did affect the softness of the deposited metal, the slower speed in the case of either straight or reversed polarity gave the softer deposit of metal. The hardness tests were made with a Shore Scleroscope and the hardness numbers given herewith are the averages of about fifty readings each.

| | STRAIGHT POLARITY | REVERSED POLARITY |
|---|---|---|
| Slow | 33 | 23 |
| Fast | 40 | 36 |

However, this should be regarded as of the nature of a hasty preliminary test which should be followed by a thoroughly careful and comprehensive research.

*Suitable Electrode*

During the progress of its investigations, the Committee found that there were a good many different kinds of electrodes in use commercially for welding cast iron. It was therefore decided to investigate these electrodes as to their respective characteristics when employed in welding cast iron.

As a preliminary project, the Committe outlined a program of investigation to be carried through with seven commercial electrodes. These comprised the following types:—

Bare wire, flux covered, alloy metal, and alloyed flux electrodes.

The Committee's investigations were confined wholly to testing these seven electrodes in accordance with the Specifications for Tests which are given below. The Committee feels, however, that further investigation is needed on some of the other items mentioned in the *Proposed Program of Research* given in the introduction.

After careful deliberation and consideration of the various elements and factors involved, the following program was adopted by the Committe as constituting a basis for a preliminary investigation, and in the belief that (with the many modifications which would doubtless be suggested as experience accumulated) it might come to be accepted as a *Standard Method of Procedure* for further investigations of this character.

## SPECIFICATIONS FOR TESTING COMMERCIAL ELECTRODES

*Size of Plate*

The size of plate shall be 40″ x 14″ x 1″. One plate shall be cast for each grade of iron to be tested.

*Method of Casting*

The plates for test shall be cast flat in a green sand mould.

*Chemical Analysis and Tensile Strength of each Material*

These data shall be obtained from the coupon bars cut from the plates as shown in Fig. 2, and compared with the data obtained from the foundry test records.

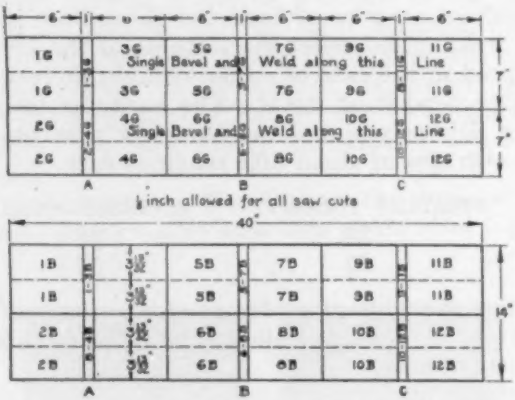



Fig. 2. Layout of plates preparatory to cutting for test plates.

*Heat Treatment*

The plates shall be allowed to cool over night in the sand of the mould to avoid any chilling action. No heat treatment shall be given to any plate.

SIZE OF SAMPLES

*For Welding*

Plates shall be laid out as shown in Fig. 2, sizes as indicated.

*For Testing of Parent Metal*

The sample test bars shall be prepared according to the specifica-

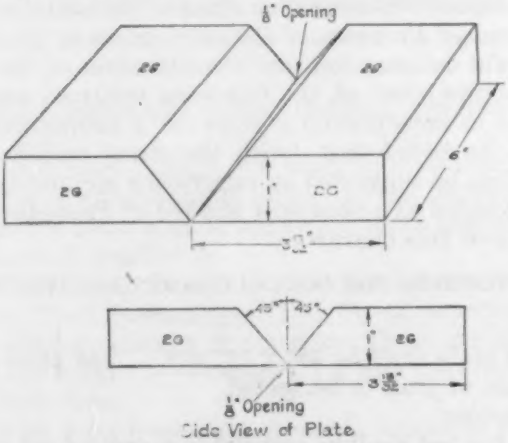



Fig. 3. Completion of plates up to time of welding.

tions of the A. S. T. M. from the coupons cut from the plate shown in Fig. 2.

## PREPARATION OF SAMPLES

*Cutting*

Plates shall first be marked as shown in Figs. 2 and 3 so that identification marks will appear on each sample, and then cut as shown on Figs. 2 and 3. As an extra precaution, after cutting, the samples shall have the same marking stamped on one short edge of each as is stamped on the surface, so that, after cutting, each sample shall bear a special mark.

*Bevelling*

45° to the center, single bevel, as shown in Fig. 3.

## METHOD OF WELDING

*Kind, Analysis, and Size of Electrodes*

The following electrodes shall be used:

| | | | |
|---|---|---|---|
| (1) | Bare wire | (6) | Alloy wire |
| (2) | Bare wire | (7) | Alloy wire |
| (3) | Coated wire | (8) | Alloy wire |
| (4) | Coated wire | (9) | Composite electrode |
| (5) | Coated wire | | |

These electrodes shall be 5/32″ in diameter, and a chemical analysis of each shall be made.

*Current*

Preferably 150 amperes in each test. The current actually used shall be recorded.

*Polarity*

Straight polarity (work positive and electrode negative) with all electrodes, and also additional samples with reversed polarity on the nickel and bronze electrodes.

*Clamping*

See Figs. 4 and 7. Plates shall be tacked at both ends and the center before the weld is started. These tack welds shall each be a single bead approximately ½″ long.

*Number of Layers*

One spiral layer only shall be deposited to fill the groove in each test. The surface of the deposited material shall extend approximately ⅛″ above the surface of the base material.

*Cleaning*

The surface of the deposited metal shall be kept clear of all scale at all times by brushing with a wire brush.

## REMARKS

After the weld has been completed the clamps shall be left in place until one's hand can be held on the weld without discomfort. No artificial cooling shall be applied.

Just before the clamps are removed the welder shall stamp an "S" on the surface of the plate at the start of the weld and an "E" at the finish. A record shall be kept of the number stamped on the sample, the type of electrode used, the welding current, the time required for making the weld, the arc characteristics of each electrode, the number, length, and total weight of electrodes used on each sample, together with the weight of scrap ends.

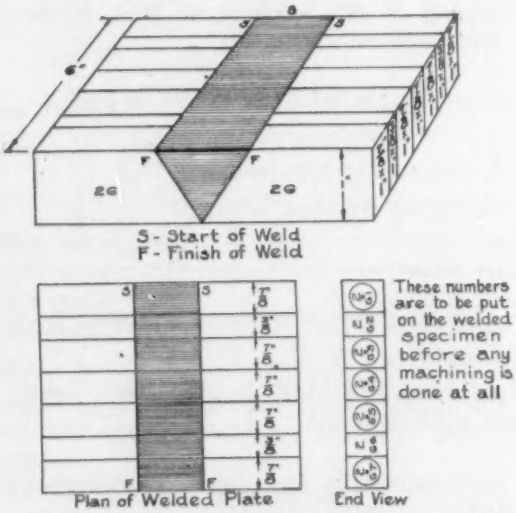

S - Start of Weld
F - Finish of Weld
These numbers are to be put on the welded specimen before any machining is done at all
Plan of Welded Plate
End View

Fig. 5. Layout of welded specimen preparatory to machining the test bars.

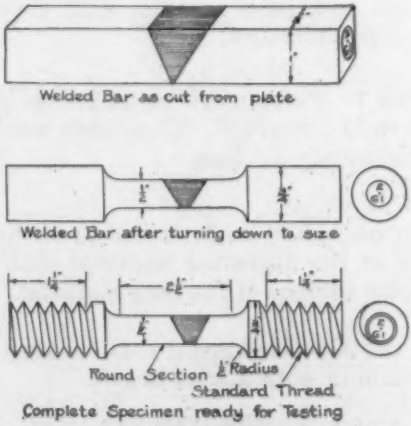



Fig. 6. Completion of specimens for testing.

## TESTING

The plates shall be laid out to be cut crosswise of the weld into five (5) bars 7/8" x 1", and two (2) bars 3/8" x 1". Beginning at the start of the weld the first bar should be a 7/8" x 1", the next a 3/8" x 1", the next three 7/8" x 1", the next 3/8" x 1", and the last 7/8" x 1". See Fig. 5. Lathe centers shall be drilled so that they will come in the center of the end of each of the 7/8" x 1" bars so laid out.

Then identifying numbers shall be stamped around the lathe centers on the 7/8" x 1" bars so that these numbers will appear on each end of each bar after the ends are turned down to 3/4" in diameter, and also on the ends of each of the 3/8" x 1" bars. The identifying numbers shall consist of the number on the sample plate followed by a numeral, this numeral being one (1) for the bar cut from the sample plate at the start of the weld and seven (7) for the bar cut from the sample plate at the finish of the weld, the intervening bars being numbered consecutively. That is, on sample plate No. 2-G the 7/8" x 1" bar at the start of the weld shall have stamped on each end 2-G-1, and the bar from the same plate at the end of the weld shall have stamped on each end 2-G-7.

The sample plates shall then be cut as laid out into the seven (7) bars, and each 7/8" x 1" bar shall be machined as shown on Fig. 6, no machining being done on the 3/8" x 1" bars.

The machinist shall keep a record of the characteristics of all of the test specimens as regards machineability of the welded portion.

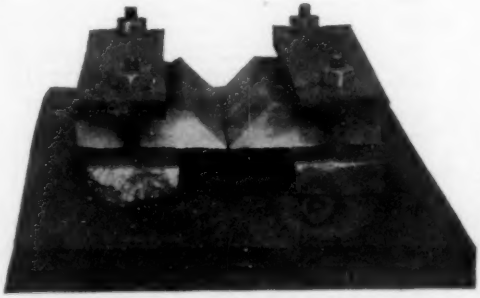


Fig. 7. Illustration of the clamping apparatus.

*Tensile Strength Tests*

Tensile strength tests shall be made on each of the round test bars in accordance with A. S. T. M. Standards.

*Hardness Tests*

Scleroscopic hardness readings shall be taken on the deposited metal, at the junction of the deposited metal and the parent metal, and on the parent metal, on each of the 3/8" x 1" test bars.

*Microscopic and Chemical Analysis*

After hardness tests have been completed on the 3/8" x 1" test bars, these shall be used to obtain microphotographs of the juncture of the deposited metal and the base metal to determine, if possible, the cause of any excessive hardness. No chemical analysis of the deposited metal shall be made unless it is determined, after the various other tests, that such analysis would be desirable on any of these specimens.

*Reports*

All data collected, with the complete history of each specimen, shall be shown on the final report, together with such conclusions as may be drawn.

## THE COMMITTEE'S TESTS

The Committee selected two different grades of cast iron as base material for the tests. These two grades of iron are identified by the letters B and G and their trade names are turbine or cylinder iron, and gray cast iron, respectively. Their chemical analyses are given in Table III A.

Two methods of depositing the filler metal were used in these tests, namely, that as described in the Specifications, and another, METHOD No. 2, which is described below.

The welds made by METHOD No. 2 were made slightly different than those made in the General Electric Company. The following diagram (Fig. 8), will illustrate the cross-section of a weld as made by this method.

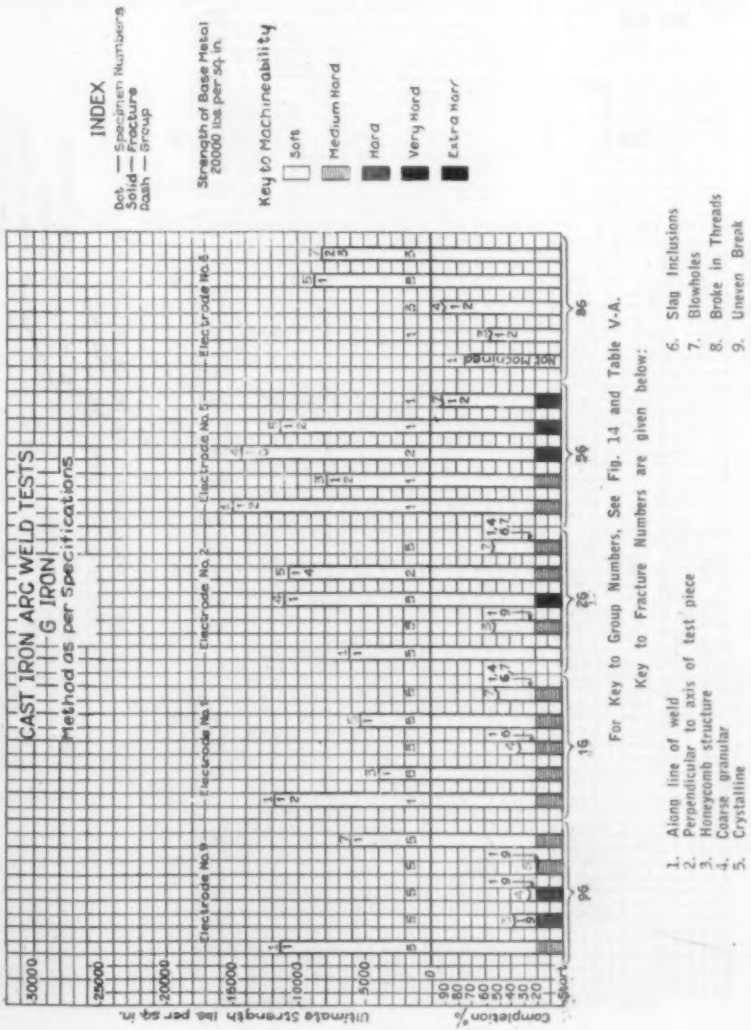
Fig. 8. Illustration of Welding. METHOD No. 2.

It will be noted from the illustration that this method allows the operator to deposit steel on the surface of the cast iron better and insures better penetration since the electrode can more easily be held perpendicular to the surface of the base metal while putting on each bead. The procedure is as follows: The parts A and B are first joined together by bead Number 1. Then beads numbered 2 and 3 are laid on so that they do not quite touch. Beads numbered 4 and 5 are next deposited and then filling 6 is laid down. More beads are laid on the cast iron and the filling-in process is continued so that the whole weld is made up of a succession of layers. The advantage claimed for this method is that the deposition of the filler metal by stages has a great tendency to anneal the deposited metal below the particular stage which

is being deposited and in this way a softer weld is obtained.

The method used to make the welds in the Welding School at Schenectady was as stated in the specifications. The filler metal was deposited in one spiral layer after the parts A and B had been joined by a single bead at the bottom of the groove. This method is claimed to prevent slag inclusions and eliminate hard spots in the weld metal. The results of the tests did not confirm the superiority of this method.

It will be noted from Table III that the *number of the electrode used has no connection at all with the number of the plate* which



was welded by that particular electrode.

In making the welds, the test plates were set up as shown in Fig. 7. During the welding operation the characteristics of the arc were carefully observed. The observations are recorded in Table 1. A study of this table will show that electrodes No. 4, 5 and 9 acted the best and electrodes No. 3 and 6 acted the worst.

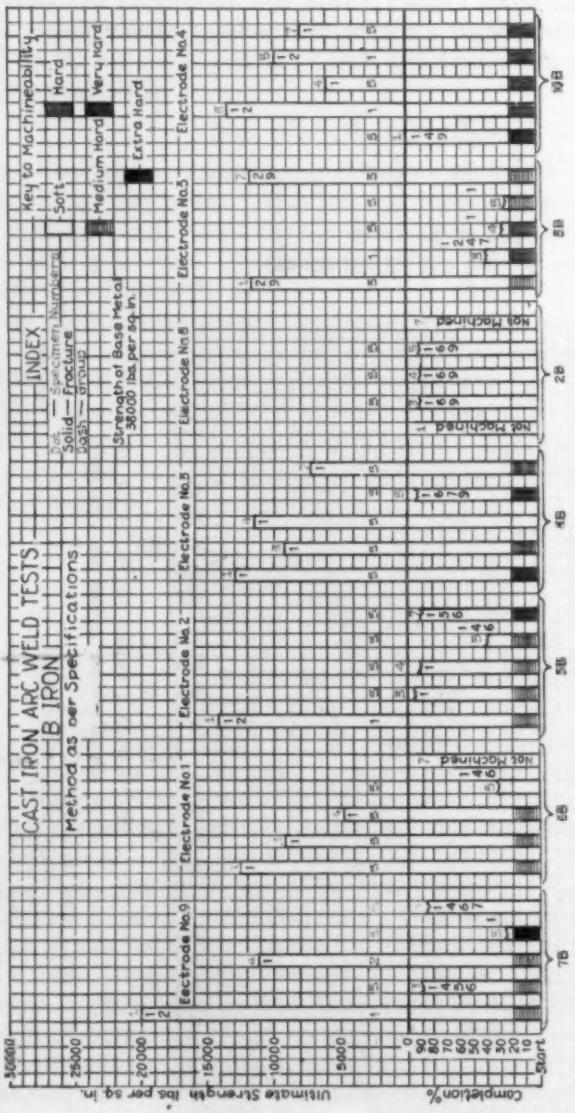



Fig. 10.

For Key to Group Numbers, See Fig. 14 and Table V-A.

Key to Fracture Numbers are given below:

1. Along line of weld
2. Perpendicular to axis of test piece
3. Honeycomb structure
4. Coarse granular
5. Crystalline
6. Slag Inclusions
7. Blowholes
8. Broke in Threads
9. Uneven Break

The time of welding and amount of electrode material used are noted in table 2.

After the welding operation had been completed the welds were allowed to cool over night in the clamps to prevent any distortion in the cooling.

While cutting the plates into strips preparatory to turning the strips into standard test bars the machinist made the comments recorded in table 7. It should be noted that G plates welded with electrodes No. 6 and 9 cut the easiest with No. 5 next. As to the B plates those welded with electrodes No. 3, 6 and 9, and the plate welded with electrode No. 1 but by METHOD No. 2 cut the easiest, the two next in order being electrode No. 1 and 5.

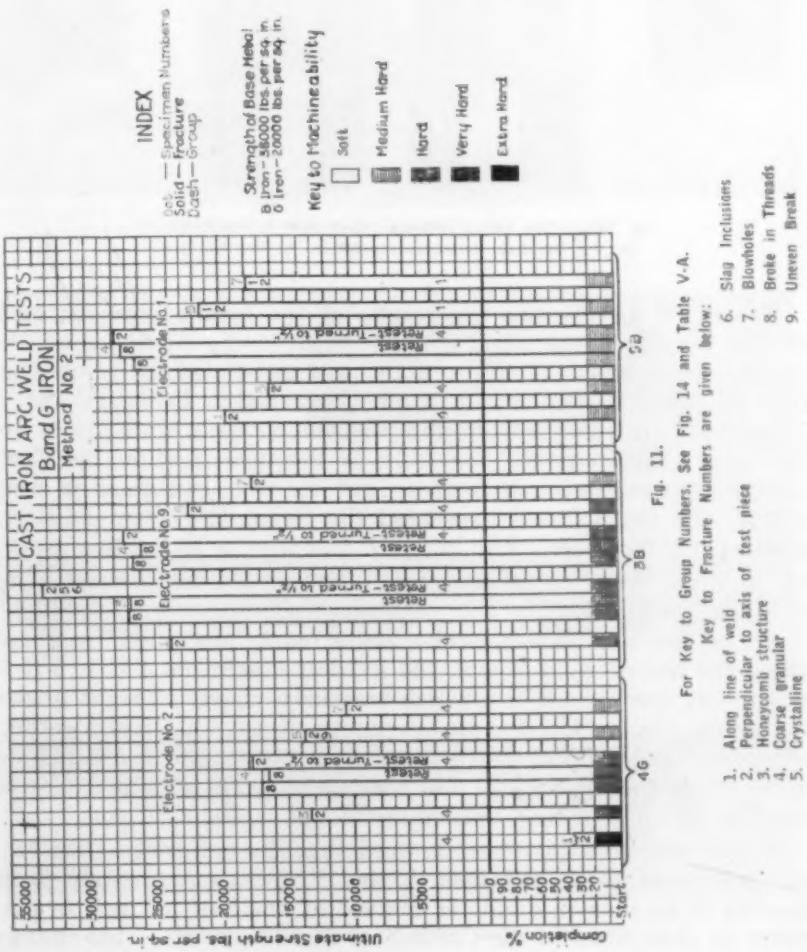



Fig. 11.

For Key to Group Numbers, See Fig. 14 and Table V-A.

Key to Fracture Numbers are given below:

1. Along line of weld
2. Perpendicular to axis of test piece
3. Honeycomb structure
4. Coarse granular
5. Crystalline
6. Slag Inclusions
7. Blowholes
8. Broke in Threads
9. Uneven Break

While turning these bars into test specimens with the lathe, the machinist attempted to classify the bars according to their machineability. This classification is used in the three charts which accompany this article as shown in Figs. 9, 10, and 11.

Fig. 12. Four Welded specimens, which broke in the threads on the first two tests, turned to one-half in. for the third test.

Tables IV and V give the results of the tensile strength tests of the various electrodes. *For the identifying numbers of the specimens see Fig. 5 of the specifications and Table III.* Note that bars No. 2 and 6 of each plate are not recorded in Tables IV and V. These bars are for hardness and microscopic tests which have not yet been completed. At the start of the investigation the Committee expected to complete these, but the time consumed in completing the tensile tests prevented the Committee from finishing the tests for hardness. *The letters B and G refer to the two grades of cast iron used.*—B to so-called turbine or cylinder iron, G to soft gray cast iron.

All of the bars which broke while being machined fractured along the line of weld except, the hardest specimens 4 G 1, 5 G 7, and a soft specimen 8 G 4 which fractured nearly at right angles to the test piece. All of these specimens except the three mentioned showed a weakness which appeared to be due to poor amalgamation between filler metal and base metal. The fracture showed varying amounts of slag, burned metal and chilled cast iron.

It will doubtless have been noticed that the majority of the tensile specimens listed in tables IV and V are approximately three fourths of an inch in diameter instead of one half an inch in diameter as prescribed in the Committee Specifications. This change

to a larger diameter was adopted by the Committee when it was found that several of the test bars were breaking in the lathe during the process of turning. The four bars 3 B 3, 3 B 4, 9 B 4, and 4 G 4 broke in the threads on two attempts to test them in the ten-

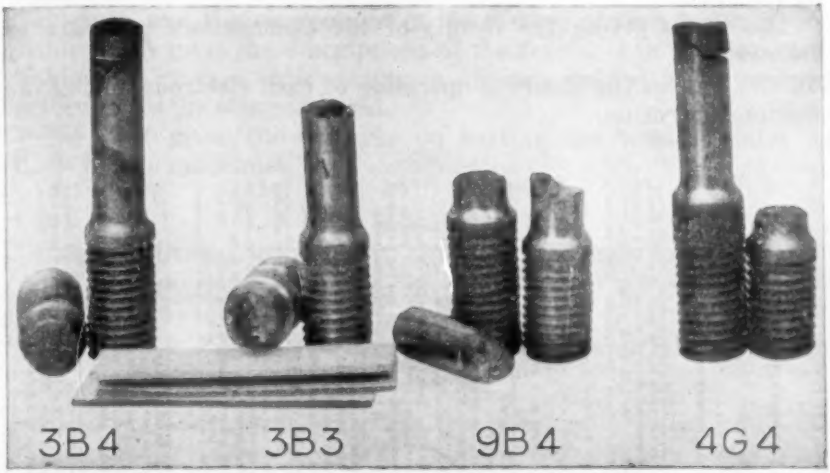



Fig. 13. Four Welded specimens of Fig. 11, after testing showing fractures.

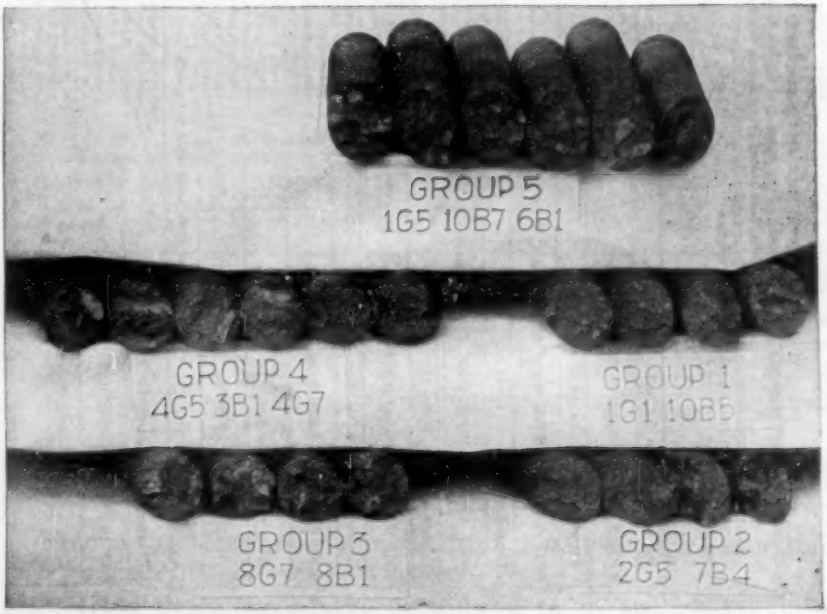



Fig. 14. Typical fractures of tensile specimens arranged in groups.

sion machine and were then turned down to approximately one half inch in diameter across the weld section as shown in Fig. 12. These four bars were tested to fracture as shown in Fig. 13. The fractures are described in Table 5 A and the grouping is illustrated in Fig. 14.

The tables giving the results of the Committee's tests are as follows:—

Table 1 gives the observed operation of each electrode during the welding operation.

TABLE I. ELECTRODES AND CHARACTERISTICS

AVERAGE CURRENT 130-150 AMP., 20 VOLTS

The Chemical Analyses Were Made by J. H. Nead of the American Rolling Mills Co. The Characteristics Were Noted When the Test Plates Were Being Welded

| Electrode | DESCRIPTION AND ANALYSIS OF ELECTRODES | | | | | | | | Welding Characteristics | Plate Used |
|---|---|---|---|---|---|---|---|---|---|---|
| | C | Mn | Si | S | Ph | Cu | Ni | Cr | Fe | |
| | Bare wire, 5/32 in. by 14 in. | | | | | | | | | |
| 1 | 0.100 | 0.466 | 0.040 | 0.025 | 0.039 | 0.056 | Trace | .... | ... | B |
| | Arc unsteady but not as bad at the start of the weld as at the finish. Deposited metal stays molten over an area of about ½ of a square inch and boils while cooling. Hard to hold a short arc for this reason. Black scum formation stops the boiling. Wire varies in workability. | | | | | | | | | |
| | Bare wire, 5/32 in. by 14 in. | | | | | | | | | |
| 2 | 0.010 | 0.012 | Trace | 0.037 | 0.021 | 0.062 | Trace | ..... | ..... | B |
| | Large arc flame. Flashy arc with small pool of molten metal which cools quickly. Metal lays solid and deposits quite evenly. This electrode works nearly the same as if on a steel plate. | | | | | | | | | |
| | Coated wire, 5/32 in. by 14 in. | | | | | | | | | |
| 3 | .... | 1.65 | 0.080 | 0.025 | 0.021 | 27.27 | 68.25 | .... | 2.29 | B |
| | Arc uneven and sputters. Deposited metal puffs up and solidifies so that, when the arc passes over it after cooling, the deposited metal melts away showing a shell-like structure. Metal is deposited unevenly and gas holes appear as the metal cools. Large bright arc flame noticeable. | | | | | | | | | |
| | Coated wire, 5/32 in. by 14 in. | | | | | | | | | |
| 4 | 0.010 | 0.010 | Trace | 0.040 | 0.019 | 0.032 | Trace | Trace | ..... | B |
| | Arc steady but sputters similar to a bare commercial electrode on a steel plate. Deposited metal lays evenly and solid but builds up slowly. A black scum forms as the metal cools but the deposited metal appears firm and solid. A smooth working electrode. | | | | | | | | | |
| | Coated wire, 5/32 in. by 18 in. | | | | | | | | | |
| 5 | 0.100 | 0.429 | 0.050 | 0.026 | 0.039 | 0.082 | Trace | .... | ... | B |
| | Steady arc similar to bare electrode on steel plate. Deposited metal seems to burn deep into the base metal and arc flame is quite noticeable. Wire burns away very fast. Electrodes were held at the third-point to prevent too rapid melting. No pool of metal to speak of. Black scum is not prominent. | | | | | | | | | |
| | Alloy wire, 5/32 in. by ... in. | | | | | | | | | |
| 6 | ... | 4.62 | 0.040 | 0.020 | 0.003 | 0.12 | 94.20 | .... | 0.70 | B |
| | *Reverse polarity necessary.* Sputtering arc. Metal deposits by dropping off in globules and boils and bubbles while cooling. The metal does not spread but bunches up. As metal cools, numerous small gas holes appear and when the arc is passed over it again the surface melts away showing a honeycombed structure. The arc burns into the base metal. Protrusions are numerous. | | | | | | | | | |
| 7 | These electrodes were not available for these tests. | | | | | | | | | |
| 8 | | | | | | | | | | |
| | Composite, 5/32 in. by 14 in. | | | | | | | | | |
| 9 | 0.080 | 0.306 | 0.050 | 0.032 | 0.022 | 0.076 | Trace | Trace | .... | B |
| | Smooth steady arc with small flame. Metal solidifies very quickly and the pool of molten metal following the arc is hardly noticeable. Appearance indicates that the heat generated in the deposited metal is small. Metal deposits where desired and solidifies quickly. A brownish white coating appears on the surface of the finished weld. | | | | | | | | | |
| | The arc characteristics were apparently the same as those already observed for the B plate, except that the arc was more unsteady and somewhat harder to maintain. The deposited metal did not stick as well to the G plate as it did to the B plate. | | | | | | | | | G |

Table II gives the data on the time required and the amount of metal consumed during the welding operation.
Table III gives the electrode used with each plate welded.
Table III-A gives the chemical analyses of the grades of iron used.
Tables IV and V give a resume of the history of each test bar.
Table V-A gives the descriptions of the fractures of the test bars.
Table VI gives a brief summary of each welded plate grouped according to the electrode used.
Table VII gives the remarks on cutting the welded plates as made by the machinist.

TABLE II

TIME REQUIRED AND METAL USED IN WELDING TEST PLATES

The weld groove was 6-in. long and 1-in. deep, beveled 90 deg., giving a volume of 6 cu. in. to top of plate. For electrode numbers see specifications.

B PLATE

Method as Per Specifications, 150 Amp., 20 Volts

| Electrode Number | Size Inches | Time Minutes | ELECTRODES | | WEIGHT | | Metal Used, Oz. |
|---|---|---|---|---|---|---|---|
| | | | Number per Lb. | Number Used | Before, Oz. | After, Oz. | |
| 1 | 5/32 by 14 | 41 | 14 | 25 2/3 | 29 1/3 | 3 2/3 | 25.8 |
| 2 | 5/32 by 14 | 37 | 14 | 22 | 25.1 | 3.4 | 22.1 |
| 3 | 5/32 by 14 | 41 | 12 | 25 | 33 1/3 | 3 | 30 1/3 |
| 4 | 5/32 by 14 | 40 | 13 1/2 | 23 | 27.3 | 4 | 23.3 |
| 5 | 1/8 by 18 | 52 1/4 | 16 | 26 1/2 | 23.5 | 4 | 22.5 |
| 6 | 5/32 by .. | 30 | .... | .... | 40 | 12 | 28.0 |
| 9 | 5/32 by 14 | 30 | 11 | 17 | 24.7 | 4 | 20.7 |

B AND G PLATES

Method No. 2. 150 Amps., 15 Volts

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2 (G plate) | 5/32 by 14 | 50 | 14 | 23 | 26.3 | 2.3 | 24 |
| 9 (B plate) | 5/32 by 14 | 35 | 11 | 20 | 29.1 | 5.3 | 23.8 |
| 1 (B plate) | 5/32 by 14 | 39 | 14 | 26 | 29.7 | 6.3 | 23.4 |

G PLATE

Method as Per Specifications, 150 Amp., 20 Volts

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | 5/32 by 14 | 40 | 14 | 22 | 25.1 | 2.9 | 22.2 |
| 2 | 5/32 by 14 | 47 | 14 | 27 | 30.9 | 3.4 | 27.5 |
| 6 | 5/32 by .. | 32 | .... | .... | 34 | 7 | 27 |
| 9 | 5/32 by 14 | 33 | 11 | 18 | 26.2 | 3.3 | 22.9 |
| 5 | 1/8 by 18 | 46 | 16 | 23 | 23 | 2 | 21 |

## CONCLUSIONS

From a consideration of the results of these tests, the Committee has reached the following conclusions,—

(1) That deposition of the filler metal to fill the weld V in a single spiral layer gives a softer but weaker weld than is afforded by depositing the filler metal in a series of parallel layers.

(2) That covering the surface of the cast iron with a layer of electrode material followed by a single spiral layer entirely filling the groove would be likely to give a weld having the desired characteristics.

(3) That the tests have shown electrodes 4, 5, 1 and 9 to give the best results for the B iron tests and electrodes 5 and 2 the best results for the G iron tests.

(4) That in so far as the variables concerned, i. e. variation of electrode strength and the personal equation of the operator may be neglected, these tests give an indication of the strength which may be expected from the various electrodes.

TABLE III

KEY TO ELECTRODES USED IN WELDING TEST PLATES

| Electrode | B Plates | G Plates |
|---|---|---|
| 1 | 6B and 9B | 1G |
| 2 | 5B | 2G and 4G |
| 3 | 8B | |
| 4 | 10B | |
| 5 | 4B | 5G |
| 6 | 2B | 8G |
| 9 | 7B and 3B | 9G |

TABLE IIIA

CHEMICAL ANALYSIS OF BASE METAL

| | B Plate Per Cent | G Plate Per Cent |
|---|---|---|
| Total carbon | 3.02 | 3.15 |
| Graphitic carbon | 2.52 | 2.96 |
| Combined carbon | 0.50 | 0.19 |
| Silicon | 1.90 | 2.28 |
| Sulphur | 0.102 | 0.104 |
| Phosphorus | 0.730 | 0.865 |
| Manganese | 0.88 | 0.55 |

(5) That while the Committee was satisfied with the specifications as drafted, there are several changes which the Committee now feels should be made before other tests are undertaken along these lines.

(6) That in the arc welding of cast iron a short, steady arc, not over 1/8" in length, is essential.

(7) That in order to decrease the importance of the personal variable the automatic arc welding machine might be used.

(8) That the grades of cast iron used by the Committee can be welded, provided reasonable care is exercised in selecting the proper electrode material which is necessary depending upon the amount of free carbon present. The operator must have had ex-

perience sufficient to enable him to properly control his arc.

(9) That the readiness with which cast iron in general can be welded is more or less dependent upon the amount of free carbon present, i. e., the more free carbon there is in the cast iron, the harder that iron is to weld. In fact some cast iron welding jobs are not successful, and yet no account is taken of the character of

TABLE IV

SUMMARY OF TESTS ON GRAY CAST IRON (G PLATES)

| Sample No. | Electrode Used | Weld Appearance Before Testing | Machineability | DIMENSIONS | | LOAD AT FAILURE | | Fracture See Key End of Table V |
|---|---|---|---|---|---|---|---|---|
| | | | | Diam. Inches | Area Sq. In. | Lb. | Lb. Per Sq. In. | |
| 2-4G | | | | 0.5 | 0.196 | 4380 | 22400 | Base Metal |
| 9-11G | | | | 0.5 | 0.196 | 3300 | 16850 | Base Metal |
| 1G1 | 1 | Poor | Medium hard | 0.757 | 0.4501 | 5305 | 11800 | 1ab |
| 1G3 | 1 | Poor | Medium hard | 0.747 | 0.4385 | 1725 | 3900 | 5a |
| 1G4 | 1 | | Medium hard. Broke (2nd cut) | | | | | 5af |
| 1G5 | 1 | Poor | Medium hard | 0.762 | 0.4560 | 2420 | 5300 | 5a |
| 1G7 | 1 | | Medium hard. Broke (4th cut) | | | | | 5adfg |
| 2G1 | 2 | Fair | Soft | 0.75 | 0.442 | 2660 | 6020 | 5a |
| 2G3 | 2 | | Medium hard. Broke (3rd or 4th cut) nearly $\frac{3}{4}$ in. | | | | | 5ai |
| 2G4 | 2 | Fair | Very hard | 0.759 | 0.4525 | 4925 | 10900 | 5a |
| 2G5 | 2 | Poor | Medium hard | 0.754 | 0.4465 | 4750 | 10600 | 2ad |
| 2G7 | 2 | | Medium hard. Broke (3rd or 4th cut) about $\frac{5}{16}$ in. | | | | | 5adfg |
| 4G1 | 2* | | Hardest of all samples. Broke (2nd cut) | | | | | 4bj |
| 4G3 | 2* | Good | Hard | 0.752 | 0.4442 | 5915 | 13300 | 4bj |
| 4G4 | 2* | Good | Hard | 0.756 | 0.4489 | 7200 | 17000 | 4h |
| 4G4 Retest | 2* | Good | Hard | 0.756 | 0.4489 | 7400 | 16500 | 4h |
| 4G4 Retest | 2* | Good | Hard | 0.5655 | 0.2512 | 4440 | 17700 | 4abj |
| 4G4 | Turned down to diameter of 0.5655 in. gave a load of 4440 lb. or 17,700 lb. per sq. in.; and broke in double fracture perpendicular to specimen, similar to 9B3. | | | | | | | |
| 4G5 | 2* | Good | Medium hard | 0.754 | 0.4465 | 6130 | 13700 | 4bijk |
| 4G7 | 2* | Fair | Medium hard | 0.749 | 0.4406 | 4675 | 10600 | 4bj |
| 5G1 | 5 | Fair | Medium hard | 0.75 | 0.442 | 6550 | 14810 | 1ab |
| 5G3 | 5 | Poor | Medium hard | 0.75 | 0.442 | 3410 | 7710 | 1ab |
| 5G4 | 5 | V.poor | Hard | 0.75 | 0.442 | 6230 | 14100 | 2af |
| 5G5 | 5 | Poor | Hard | 0.75 | 0.442 | 4950 | 11200 | 1ab |
| 5G7 | 5 | | Hard. Broke (last cut) | | | | | 1ab |
| 8G1 | 6 | | Undersized. Not machined | | | | | |
| 8G3 | 6 | | Soft. Broke | | | | | 1ab |
| 8G4 | 6 | | Soft. Broke (last cut) | | | | | 3ab |
| 8G5 | 6 | V.poor | Soft | 0.768 | 0.4633 | 4040 | 8700 | 1a |
| 8G7 | 6 | Poor | Soft | 0.762 | 0.4560 | 3675 | 8100 | 3bck |
| 9G1 | 9 | Poor | Medium hard | 0.755 | 0.4477 | 5040 | 11300 | 5a |
| 9G3 | 9 | | Hard. Broke (2nd or 3rd cut) | | | | | 5ai |
| 9G4 | 9 | | Hard. Broke (1st cut) | | | | | 5ai |
| 9G5 | 9 | | Medium hard. Broke (putting in center mark) | | | | | 5ai |
| 9G7 | 9 | Poor | Medium hard | 0.762 | 0.4560 | 2735 | 6000 | 5a |

* Method No. 2 used.

the casting, but the welding process is blamed for the failure.
(10) That some so-called cast iron castings are not really cast iron

TABLE V

SUMMARY OF TESTS ON TURBINE OR CYLINDER IRON (B Plates)

| Sample No. | Electrode Used | Weld Appearance Before Testing | Machineability | DIMENSIONS | | LOAD AT FAILURE | | Fracture See Key End of Table V |
|---|---|---|---|---|---|---|---|---|
| | | | | Diam. Inches | Area Sq. In. | Lb. | Lb. Per Sq. In. | |
| 2-4B | | | | 0.5000 | 0.1964 | 7490 | 38100 | Base Metal |
| 9-11B | | | | 0.5 | 0.196 | 7630 | 38900 | Base Metal |
| 2B1 | 6 | | Undersized. Not machined | | | | | |
| 2B3 | 6 | | Broke. Turned to ¾ in. | | | | | 5afi |
| 2B4 | 6 | | Broke | | | | | |
| 2B5 | 6 | | Broke | | | | | 5i |
| 2B7 | 6 | | Undersized | | | | | 5i |
| 3B1 | 9* | Fair | Hard | 0.761 | 0.4548 | 10755 | 23700 | 4bj |
| 3B3 | 9* | Fair | Hard | 0.753 | 0.4453 | 12000 | 26900 | 4h |
| 3B3 Retest | 9* | Fair | Hard | 0.753 | 0.4453 | 11900 | 26700 | 4h |
| 3B3 Retest | 9* | Good | Hard | 0.575 | 0.2597 | 7065 | 27200 | 4bk |
| 3B3 | Turned to diameter of 0.575 in. gave a load of 7065 lb. or 27,200 lb. per sq. in.; and broke perpendicular to specimen, 20 per cent in cast iron, large black spot | | | | | | | |
| 3B4 | 9* | Fair | Hard | 0.758 | 0.4513 | 11950 | 26500 | 4h |
| 3B4 Retest | 9* | Fair | Hard | 0.758 | 0.4513 | 11680 | 25900 | 4h |
| 3B4 Retest | 9* | Good | Hard | 0.570 | 0.2552 | 8540 | 33360 | 4bj |
| 3B4 | Turned to diameter of 0.570 in. gave a load of 8540 lb. or 33,360 lb. per sq. in.; and broke at right angles in cast iron | | | | | | | |
| 3B5 | 9* | Fair | Hard | 0.741 | 0.4313 | 9620 | 22300 | 4bj |
| 3B7 | 9* | Good | Medium hard | 0.753 | 0.4453 | 7880 | 17450 | 4bjk |
| 4B1 | 5 | Poor | Hard | 0.755 | 0.4477 | 5765 | 12900 | 5a |
| 4B3 | 5 | Poor | Medium | 0.750 | 0.442 | 4050 | 9180 | 5a |
| 4B4 | 5 | Poor | Soft | 0.755 | 0.4477 | 5110 | 11400 | 5a |
| 4B5 | 5 | | Hard. Broke (all but threaded) | | | | | 5afgi |
| 4B7 | 5 | V. poor | Medium hard | 0.755 | 0.4477 | 3200 | 7200 | 5a |
| 5B1 | 2 | Poor | Medium hard | 0.75 | 0.442 | 6250 | 14150 | 1ab |
| 5B3 | 2 | | Broke. Nearly complete | | | | | 5a |
| 5B4 | 2 | | Medium. Broke (last cut) | | | | | 5a |
| 5B5 | 2 | | Medium. Broke (2nd or 3rd cut) | | | | | 5adf |
| 5B7 | 2 | | Hard. Broke (last cut) | | | | | 5aef |
| 6B1 | 1 | Poor | Medium hard | 0.749 | 0.4406 | 5540 | 12600 | 5a |
| 6B3 | 1 | Poor | Medium hard | 0.742 | 0.4324 | 3960 | 9200 | 5a |
| 6B4 | 1 | Poor | Medium hard | 0.752 | 0.4442 | 2130 | 4800 | 5a |
| 6B5 | 1 | | Soft. Broke (2nd cut) | | | | | 5adf |
| 6B7 | 1 | | Undersized. Not machined | | | | | |
| 7B1 | 9 | Poor | Medium hard | 0.749 | 0.4406 | 8850 | 20100 | 1a |
| 7B3 | 9 | | Broke (nearly complete threaded) | | | | | 5adef |
| 7B4 | 9 | Poor | Medium hard | 0.741 | 0.4313 | 4850 | 11200 | 2a |
| 7B5 | 9 | | Harder than flint. Broke (1st or 2nd cut) | | | | | 4a |
| 7B7 | 9 | | Broke (turning down last cut apparently soft) | | | | | 5adfg |

* Method No. 2 used.

TABLE V—(Cont'd)

| Sample No. | Electrode Used | Weld Appearance Before Testing | Machineability | DIMENSIONS | | LOAD AT FAILURE | | Fracture See Key End of Table V |
|---|---|---|---|---|---|---|---|---|
| | | | | Diam. Inches | Area Sq. In. | Lb. | Lb. Per Sq. In. | |
| 8B1 | 3 | Poor | Medium | 0.755 | 0.4477 | 5175 | 11600 | 3bik |
| 8B3 | 3 | | Hard. Broke (2nd or 3rd cut) to $\frac{1}{16}$ in.) | | | | | 1abdg |
| 8B4 | 3 | | Hard. Broke (1st cut complete) just started | | | | | 5ik |
| 8B5 | 3 | | Medium. Broke (1st cut) | | | | | 5ik |
| 8B7 | 3 | Fair | Medium | 0.725 | 0.4128 | 4830 | 11700 | 3bik |
| 9B1 | 1* | Fair | Medium hard | 0.748 | 0.4394 | 8525 | 19400 | 4bk |
| 9B3 | 1* | Good | Medium hard | 0.750 | 0.4418 | 7100 | 16100 | 4bj |
| 9B4 | 1* | Good | Medium hard | 0.758 | 0.4513 | 11810 | 26200 | 4h |
| 9B4 Retest | 1* | Good | Medium hard | 0.758 | 0.4513 | 12320 | 27300 | 4h |
| 9B4 Retest | 1* | Good | Medium hard | 0.575 | 0.2597 | 7230 | 27800 | 4bj |
| 9B4 | Turned to diameter of 0.575 in. gave a load of 7230 lb. or 27,800 lb. per sq. in.; and broke in double fracture perpendicular to test specimen at end of weld. | | | | | | | |
| 9B5 | 1* | Good | Medium hard | 0.75 | 0.442 | 9420 | 21300 | 1ab |
| 9B7 | 1* | Fair | Medium hard | 0.748 | 0.4394 | 7820 | 17800 | 1ab |
| 10B1 | 4 | Poor | Very hard. Broke two blows on edge of table | | | | | 5a |
| 10B3 | 4 | Good | | 0.75 | 0.442 | 5 20 | 13400 | 1ab |
| 10B4 | 4 | Poor | Hard | 0.762 | 0.4560 | 2960 | 5900 | 5a |
| 10B5 | 4 | Poor | Hard | 0.752 | 0.4442 | 4360 | 9800 | 1ab |
| 10B7 | 4 | V. poor | Hard | 0.759 | 0.4525 | 3590 | 7900 | 5a |

* Method No. 2 used.

KEY TO REMARKS ON FRACTURE AND GROUP

(a) Along line of weld.
(b) Perpendicular to axis of test piece.
(c) Honeycomb structure.
(d) Coarse granular.
(e) Crystalline.
(f) Slag inclusions.
(g) Blow holes.
(h) Broke in threads.
(i) Uneven break.
(j) In the cast iron.
(k) In the weld.

(1) Group 1.
(2) Group 2.
(3) Group 3.
(4) Group 4.
(5) Group 5.
(See Table Va).

but rather badly burned iron which cannot be welded. Such jobs should not condemn the cast iron welding process.

(11) That these tests are insufficient in number to be considered as a finished research, but that they are suggestive of further lines of investigation.

(12) That the standard test bar for cast iron should be larger than that prescribed by the American Bureau of Welding, i. e., the Welding Standard for brittle materials should be similar to the test bar recognized by the American Society for Testing Materials.

The A. S. T. M. Standard Tension Test for Cast Iron as given in the 1921 issue of the Society is as follows,—

"When tension tests are specified, the tension test specimens shall be turned from any of the broken pieces of the transverse

test specimens, and shall conform to the dimensions shown in Fig. 2."

These dimensions are as follows:—
1¼" threaded ends, standard thread over 1" section. ¼" shoulder

TABLE Va

## CHARACTER OF FRACTURE AFTER BREAKING SPECIMENS IN TENSILE TEST

(See Fig. 14)

### GROUP 1

Fracture partly through the cast iron at right angles to specimen and then along the line of weld.

| | |
|---|---|
| 1 G 1 | 25 per cent through cast iron. Weld pulled-out some cast iron. 10 per cent burned metal |
| 8 G 5 | 30 per cent through cast iron. Weld metal surface coarse granular |
| 5 G 1 | 60 per cent through cast iron. Balance badly burned |
| 10 B 5 | 20 per cent through cast iron. Large pigeon blue spot at edge of weld metal about ⅝ in. by ¼ in. |
| 7 B 1 | 40 per cent through cast iron. Balance badly burned metal |
| 9 B 7 | 40 per cent through cast iron. Burned metal lighter than 7 B 1 |
| 5 B 1 | 50 per cent through cast iron. About 15 per cent burned metal. Remainder grayish color with pockmarks |
| 10 B 3 | 60 per cent through cast iron. Balance dark grayish metal |
| 9 B 5 | 70 per cent through cast iron. Dark brown spots in weld metal. Flaw in base metal due to undersized bar before turning |
| 5 G 5 | 30 per cent through cast iron. Balance pockmarked, cat's paw structure |
| 5 G 3 | 60 per cent through cast iron. Balance burned metal |

### GROUP 2

Similar to Group 1 except that break through cast iron was not at right angles to the test specimen but rather parallel to line of weld.

| | |
|---|---|
| 5 G 4 | 20 per cent through cast iron. 50 per cent good metal. Some slag |
| 2 G 5 | 20 per cent through cast iron. Grayish brown granular surface |
| 7 B 4 | 50 per cent through cast iron. Varicolored slag section |

### GROUP 3

Fracture at right angles to test specimen and very irregular on the surface. Break at center of weld.

| | |
|---|---|
| 8 B 1 | Coarse granular and full of gas pockets. Very porous |
| 8 B 7 | Coarse granular and full of gas pockets. Very porous |
| 8 G 7 | Coarse granular and full of gas pockets. Very porous |

### GROUP 4

Fracture at right angles to specimen. Surface quite smooth and regular. An ideal tension fracture.

| | |
|---|---|
| 3 B 7 | 90 per cent through cast iron. Weld metal rather fibrous |
| 3 B 1 | 80 per cent through cast iron. Fine granular spot between cast iron and weld metal |
| 3 B 5 | 50 per cent through cast iron. 50 per cent through weld |
| 9 B 1 | 40 per cent through cast iron. Remainder dark bluish metal like slag |
| 9 B 3 | 90 per cent through cast iron. Balance weld metal as before. Double fracture. Second fracture 50 per cent complete nearly along line of weld |
| 4 G 3 | 90 per cent through cast iron |
| 4 G 5 | Uneven break 50 per cent through cast iron. 50 per cent through weld metal. Alternating layers of light and dark metal |
| 4 G 7 | 90 per cent through cast iron similar to specimen 9 B 3 |

TABLE Va (Continued)

CHARACTER OF FRACTURE AFTER BREAKING SPECIMENS IN TENSILE TEST

GROUP 5

Break occurred along the line of weld junction showing various degrees of amalgamation.

| | |
|---|---|
| 4 B 4 | Pitted surface showing series of warts like bottom of cat's paw. Irregular |
| 6 B 1 | Blotched appearance with very uneven surface |
| 10 B 4 | Pitted surface but of lesser degree than 4 B 4. Colors of metal darker |
| 6 B 3 | Blotched dark gray and light gray. Slag ball pulled out of weld metal size of pea |
| 4 B 1 | Blotched appearance but somewhat smoother than 4 B 4 |
| 9 G 7 | Similar to 4 B 4. Large slag inclusion size of pea |
| 4 B 7 | Pitted surface. Series of cold spots like a cat's paw. Evidently poor amalgamation |
| 2 G 4 | Irregular surface. Cast iron pulled away to some extent |
| 9 G 1 | Pockmarked surface, somewhat smoother than 4 B 4 and 4 B 7 |
| 6 B 4 | Somewhat smoother than 4 B 4 and 4 B 7 |
| 10 B 7 | Same as 4 B 7 |
| 1 G 5 | Same as 4 B 7 |
| 1 G 3 | Same as 4 B 7 |
| 2 G 1 | Quite smooth surface. Somewhat pockmarked. Some light crystalline sections overlaid by a scum of olive drab color |
| 4 B 3 | Blotched appearance. Light gray, fine grained areas intermingled with dark blue and olive drab. Insufficient fusion |

BROKE THROUGH THREADS ON FIRST TWO TESTS

These specimens broke in the threads on two tests with the results as given previously. The third time, the bars were turned down to ½ inch diameter over the welded section and tested. The fractures are as described.

THIRD TEST

| | |
|---|---|
| 3 B 3 | Same as Group 4. 20 per cent cast iron shows. Balance is filler metal which shows a large dark area about 40 per cent of the entire surface. This is evidently a slag inclusion |
| 3 B 4 | Same as Group 4. Through cast iron at end of filler metal. Ideal tension fracture |
| 9 B 4 | Similar to 9 B 3, Group 4. Fracture through cast iron at end of weld, about 2 per cent of weld metal showing. Second fracture 10 per cent complete across cast iron |
| 4 G 4 | Similar to 9 B 3, Group 4. Fracture through cast iron at end of weld, about 5 per cent weld metal showing. Second fracture about 75 per cent complete, 20 per cent through cast iron. Balance along line of weld and then 20 per cent held by filler metal |

1″ in diameter betwen threads and test section. The middle section of the bar shall be turned to 0.8″ diameter with a 7/32″ radius at each end to connect with 1″ shoulder. The total length of the test section from shoulder to shoulder is 1″ and the total length of the test specimen is 3½″ over all.

This test specimen might be lengthened for welding test specimens for the purpose of a clear section to be turned across the weld.

Prof. Frank P. McKibben, Professor of Civil Engineering at Union College is quoted as follows:—

"It would seem that the standard desired is some standard method of testing which would eliminate the great amount of machining necessary in turning out test bars. I would like to suggest a transverse bending test on a test bar of standard size. Such a bar

TABLE VI

PREPARATION OF TEST SPECIMENS

| Plate | Electrode Used | WELDING | | MACHINING | | |
|---|---|---|---|---|---|---|
| | | Time (Minutes) | Metal (Ounces) | Cutting (Hours) | Broke in Lathe Specimen Number See Tables IV & V | Remarks Hardness |
| 2B | 6 | 30 | 28 | 3 | 3, 4 and 5 | (S) |
| 8G | 6 | 32 | 27 | 3 | 3 and 4 | (S) |
| 5B | 2 | 37 | 23.2 | 3¾ | 3, 4, 5 and 7 | (MH) |
| 2G | 2 | 47 | 27.5 | 3½ | 3 and 7 | (MH) |
| 4G | 2 | 52 | 24 | 5¾ | 1 (1st cut V.V.H.) | (H) |
| 6B | 1 | 41 | 25.8 | 3 | 5 | (MH) |
| 1G | 1 | 40 | 22.2 | 4¼ | 4 and 7 | (MH) |
| 9B | 1 | 39 | 23.4 | 3 | None | (MH) |
| 7B | 9 | 30 | 20.7 | 3 | 3, 5 and 7 | (MH) |
| 9G | 9 | 33 | 22.9 | 3 | 3, 4 and 5 | (MH) |
| 3B | 9 | 35 | 23.8 | 8⅔ | None | (VH) |
| 4B | 5 | 52½ | 23.0 | 3¼ | 5 | (MH) |
| 5G | 5 | 46 | 21 | 3¾ | 7 | (MH) |
| 10B | 4 | 40 | 23.3 | 7 | 1 | (H) |
| 8B | 3 | 41 | 30 | 3 | 3, 4 and 5 | (H.S.) Hard spots |

could be easily made without much machining and probably without breaking as many test specimens as occurred in the Committee tests."

During the process of the investigations, the Committee has formulated several questions which, as yet, have not been satisfactorily and conclusively answered. An attempt has been made to outline a program of research and the solution of each point has an important bearing on the final conclusions.

1. What is the correct method of depositing the filler metal to secure a machineable weld with maximum strength.
2. Will preheating the welding surface with a carbon arc help in binding the filler and base metals?
3. What current is best for obtaining the strongest adhesion between filler and base metals?
4. Does the phosphor-bronze electrode offer any advantages as an antidote for the hard zone?
5. What advantages are offered by the use of a nickel electrode?
6. Does brushing the surface of each layer with a wire brush strengthen the weld?
7. How much is the hardness dependent on the speed of cooling?
8. Will silicon soften the filler metal in the weld?
9. Will hammering each layer of deposited metal while welding increase the strength of the weld?
10. What is the best way to apply the filler metal to secure the maximum strength, requisite softness, and minimum contraction?
11. What kind of electrode and what method of welding contribute to least porosity?

TABLE VII

MACHINIST'S REMARKS ON CUTTING THE WELDED PLATES

| Plate | Electrode No. | Time of Cutting, Hours | Remarks on Cutting |
|---|---|---|---|
| 1 G | 1 | 4¼ | Plate cut under difficulties although the welded portion was no harder than usual. Rather stringy metal in the welded portion causing saw teeth to clog especially after cutting the first three test pieces. From the fourth test piece, the balance of plate required two cuts on each test piece before taking the entire thickness. The machine had to be stopped quite frequently to remove chips from the saw teeth, when passing through the welded section. |
| 2 G | 2 | 3½ | First four test pieces were cut using same saw as was used in cutting the six test pieces from Plate 5 B. While cutting the fifth test piece, the saw struck a real hard spot which took the entire cutting edge from the saw. A new saw was used to complete the plate. This plate was quite hard in general but was able to cut through the entire thickness of each piece by raising and lowering the table to prevent stopping of saw. |
| 4 G | 2 Method No. 2 | 5¾ | Plate was exceedingly hard, requiring the use of three saws and taking two cuts on each test piece. Entire plate was hard not only in welded portion but also through the cast iron. |
| 5 G | 5 | 3¾ | Plate machined fairly well but metal at junction of filler and base metals was hard. The hard junction and crust on top of welded section made it necessary to raise and lower the table to prevent the saw from stopping. One saw was used on the entire plate. |
| 8 G | 6 | 3 | Plate cut very good. Entire thickness of plate was taken in one cut using same saw as was used on Plate 8 B. The weld section was no harder than usual. |
| 9 G | 9 | 3 | Entire plate was cut with one saw taking the entire thickness of the plate in one cut. The welded section had no effect on the saw in the least aside from the effect of the scale and grit. |
| 2 B | 6 | 3 | Plate cut excellently, being cut into test pieces with one saw taking the entire thickness in one cut. Welded section had no effect on the saw aside from the effect of the scale and grit. |
| 3 B | 9 Method No. 2 | 8⅔ | Entire plate was very, very, exceedingly hard requiring the use of 14 saws before the plate was completed. One saw was totally destroyed as it pulled in two under the strain of the hard welded sections. Plate was raised and lowered repeatedly to allow saw to cut through. |
| 4 B | 5 | 3¼ | Entire plate was machined with same saw as was used on Plate 2 B, taking entire thickness of plate per cut up to last test piece which required two cuts. The welded portion of the whole plate was real hard and probably be hard to turn. |
| 5 B | 2 | 3¾ | The first cut was very hard requiring the use of three saws and taking two cuts for the test piece. After securing the first piece a sharp saw was placed on the arbor and the entire plate completed with it, taking the entire thickness of plate at one cut. |

TABLE VII (Continued)

MACHINIST'S REMARKS ON CUTTING THE WELDED PLATES

| Plate | Electrode No. | Time of Cutting, Hours | Remarks on Cutting |
|---|---|---|---|
| 6 B | 1 | 3 | Plate machined very nicely. Used same saw that finished last two cuts on Plate 2 G, taking entire thickness of plate per cut. In fact this plate machined similar to Plate 7 B although the welded section was much harder. |
| 7 P | 9 | 3 | Plate machined excellently, the entire plate being cut into test pieces with one saw taking the entire thickness of the plate per cut. The welded section did not seem to affect the saw in the least. |
| 8 B | 3 | 3 | A sharp saw was placed on the arbor and the entire plate was machined with it taking the entire thickness of the plate in one cut. Aside from the welded portion being somewhat hard the plate worked up excellently. |
| 9 B | 1 Method No. 2 | 3 | Plate machined excellently taking the entire thickness of the plate in one cut. The welded portion did not seem to be very hard but rather tough. |
| 10 B | 4 | 7 | First cut was extremely hard, requiring five different cuts to go through the plate, practically destroying the saw. The entire plate was quite hard in general, requiring three cuts or more to each test piece also the changing of saws for each piece until the last cut which was made through the entire plate in one cut. |

## GLOSSARY

The Committee has attempted to define several phrases which have been used in this paper:

*Penetration*

The word "penetration" is used indiscriminately in referring to welding work. The welder should make a distinction between "heat penetration" and "weld penetration." It is agreed by those who have studied the welding art that there is a difference between the depth to which the base metal is melted and the depth to which the amalgamation of the filler and base metals extend. This latter depth is usually what is spoken of as "penetration".

## POLARITY

In steel welding the usual practice is to make the work positive and the electrode negative. This is called "straight" polarity. When the electrode is positive and the work or base metal is negative, the welder calls this condition "reversed" polarity.

## SPEED OF WELDING

All references to speed of welding have been more or less understood to be a designation of the comparative rate of travel of the electrode without regard to the rate of deposition of metal from the electrode. There is no standard unit of measurement of speed of welding. As a matter of fact no one can specify a certain speed

and be sure of obtaining desired results unless the amount of current is also specified.

COLD SHUT

A "cold shut" is produced when any part of the surface of an ingot freezes before the mold has been filled, due to an interruption of the stream of metal.

OPEN GRAINED

The term "open grained" refers to irons, the fractures of which show large grains.

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## WHAT OTHER JOURNALS THINK ABOUT OUR WORK IN THE ELECTRIC RAILWAY FIELD.

*Editorial appearing in the October 14th, 1922 issue of the Electric Railway Journal, page 624.*

### Co-operation with Welding Society Is Commendable

The joint meeting between the American Welding Society and the Engineering Association in Chicago was a good thing as far as it went. Unfortunately it did not go far enough. There was a symposium of six good papers, covering as many phases of the subject, but they elicited no discussion on this extremely active and interesting topic. It must be admitted that circumstances were not conducive to discussion. The weather was uncomfortably hot, the meeting room was noisy due to sounds drifting in from outside, and the symposium came at the end of a busy session. Moreover, there was such a wealth of material presented that it was difficult to pick out the high spots for discussion. The papers were not available for members in advance, although copies of the *Journal* of the American Welding Society, containing all of them, were distributed at the meeting.

In spite of the meager results of the meeting, however, as judged by the lack of discussion, the joint session was an excellent start in the right direction. It augurs well for pleasant and profitable future relations between the two organizations. Welding has come to be such an important adjunct in electric railway maintenance work that electric railway engineers ought to have the best available information on the subject. This they can undoubtedly get by affiliation with the American Welding Society.

Relations with the Welding Society are bound to become more intimate as the rail-joint tests develop. These have been promulgated by the American Bureau of Welding committee on welded rail joints, and the American Association is going to back them up financially. Through this affiliation the Engineering Association not only gets the benefit of the experience of the welding experts, but it comes in touch with the National Research Council, a na-

tional organization of high scientific and practical standing. Hence, while the initial meeting of the "welders" and the railway engineers at Chicago was something of a disappointment, this can be overlooked when it is viewed as the beginning of a larger and larger co-operation.

When the American Welding Society and the Engineering Association meet again, it might be well to devote a whole session to their mutual interests.

### Engineers Must Now Make Good on Rail-Joint Tests

*Editorial appearing in the Electric Railway Journal, October 14th, 1922, page 624.*

The American Association's executive committee has shown its confidence in the engineers of the electric railway industry, and in the American Electric Railway Engineering Association, by the action taken last Friday on the request from the latter association for an appropriation of funds to finance certain tests to be made on welded rail joints. By granting the sum of $10,000 outright and making provision for raising an additional equal amount by a special canvass, the association makes possible an ambitious and promising program of research. If this program is carried out in the same spirit of foresight and persistance that has been manifested up to this point, the result will be of great money value to the industry and will enhance the reputation of the Engineering Association among engineers and executives.

The financial plan adopted is an equitable one because it provides, first, for the general distribution of part of the cost of the tests over practically the entire industry. The remainder of the cost is to be provided by the companies, railway and manufacturing, which will most directly and most largely benefit from the work. The plan is a wise one, further, because it will give the maximum of stimulus to the achievement of practical results. That is to say, the association management plus each individual contributor will constitute an informal committee to insure the prompt completion of the work. The spirit of the engineers who are back of the movement is such as to guarantee an active and intelligent pushing of the program, but these men are human, and it will do them no harm to have as a spur the expectancy of results on the part of those who have put up the money.

The Engineering Association and its committee on way matters have shouldered a considerable responsibility in asking for financial support for their tests, and in assuring the American Association's executive committee that the tests will be worth while. It is now up to them to "deliver the goods." This, of course, will take time. No one will expect worth-while results in a few weeks or even months. It will take years to complete the research. On the other hand, the big "merry-go-round" joint-testing machine

should be available for use next spring, and some interesting data should be available for discussion at the 1923 convention of the Engineering Association.

## THE WELDED RAIL JOINT TESTS

*Article appearing in November, 1922, AERA, pages 444-446.*

### Apporpriation of $10,000 by American Association and Contributions from Companies to be Used in Developing Best Joints and Best Methods of Application

Action by the Executive Committee of the American Electric Railway Association in making an appropriation of $10,000 and the offer of several of the larger electric railway companies to contribute amounts up to $1,000 for the purpose of financing the rail joint testing machine proposed by the Way Committee of the Engineering Association and to continue the research work on welded rail joints under the auspices of the Engineering Association and the American Bureau of Welding should be especially gratifying to the industry. The research work as proposed is not intended to develop the relative merits of the various types of welded rail joints now being manufactured. It is the intention, however, to collect data which will be of assistance in improving the technique of the manufacture of each type of welded rail joint and to develop the most advantageous and economical methods of applying the various types of joints. While bearing in mind the desirability of cheapening the various joint welding processes, the main point is to insure their dependability for the longest possible period of time.

The welded rail joint as a general type of joint, gives promise of ultimately lessening track maintenance costs to very great degree but the welded joints in use today are being installed with little or no scientific data as to the correct procedure in their production. Welded rail joints offer large savings in the electrical and power departments. First costs of bonding are avoided and the steady drains due to wasted power and low voltage are practically eliminated if the joints remain good. Electric railway companies all over the country are installing thousands of joints every year and in many cases using methods and variations in processes which have been tried elsewhere and found unsatisfactory, or the ultimate effects of which are entirely unknown.

Many prominent electric railway officials have expressed favorable opinions of the proposed research program. Although some officials are not entirely satisfied that the results to be obtained from such tests as are contemplated will prove conclusive, yet all have agreed that if the results anticipated by the Committee are achieved, the industry will be benefited immeasurably and many

thousands of dollars now spent in repairing and renewing joints will be saved, making the expense of the tests insignificant.

The 1920 Way Committee of the American Electric Railway Engineering Association recommended that steps be taken to secure reliable information on the comparative merits of all known forms of welded rail joints. The committee consulted the United States Bureau of Standards which offered to co-operate if this Association would finance one-half the costs of the suggested series of tests, but as no funds were available for such purposes, the project was temporarily abandoned.

The 1921 Way Committee succeeded in securing the co-operation of the Bureau of Standards, American Bureau of Welding and some manufacturing interests in the formation of the special committee now known as the Committee on Welded Rail Joints. The American Electric Railway Engineering Association also got behind the Committee and President Gove appointed Messrs. Ryder and Steward as representatives of the Association on the Welded Rail Joint Committee. It was stipulated that no obligation as to funds went with this representation and to date the Committee on Welded Rail Joints has been financed by the National Research Council, American Bureau of Welding and the Third Avenue Railway Company of New York City, which organizations have donated secretarial services and also the printing costs for a comprehensive progress report of 73 pages recently issued by the Committee.

The 1922 Way Committee was instructed to follow the work of the Committee on Welded Rail Joints and all members of Sub-committees No. 5 (Arc Welded Joints) of the Way Committee are members of the Committee on Welded Rail Joints. Thus the work of the latter committee has been followed closely.

It was clearly realized that what was needed in this important study was an equipment which would permit making practical service tests so that the results of the investigation might be presented to the industry with the least possible delay. In March, 1922, Sub-committee No. 5 of the Way Committee of the Engineering Association of which Mr. W. W. Wysor was chairman, presented for discussion, a rotary testing machine which seemed to fulfill the requirements of the contemplated tests. A drawing and description of the proposed testing machine was published in the June 17, 1922, issue of the Electric Railway Journal and also is included in the 1922 Report of the Way Committee.

Briefly the machine is to consist of eight two-wheel trucks mounted tandem fashion, operating on a circular single rail track having a radius of 40 feet. The trucks are to be mounted on light structural frames, eight in number, said frames constructed as radial arms, the trucks being on the outer ends of the arms and the inner ends converging to a common center. Two of the trucks located opposite each other are to be propelled by motors designed

to stand continuous operation.

The wheels are to be ordinary car wheels, either cast iron or steel, and the journal boxes and bearings are as nearly as possible to conform with standard designs. The track will be formed of the rails and joints, which it is desired to test. The rail will be spiked to cross ties laid on stone ballast supported on a concrete slab. The ground immediately inside the track is to be excavated to a depth of not less than 6½ feet so as to permit an observer to stand inside and make observations while the machine is in motion.

The primary purpose of this machine is to test various types of rail joints, but it will also be valuable in testing rails, wheels, axles, bearings, motors, etc. It is proposed to operate this machine at peripheral speed of 25 miles per hour, and it is assumed that it will operate for 22 hours per day, six days per week. It will be possible in a period of five weeks to obtain results equivalent to 3 to 10 years of service, depending on whether the service be heavy, medium or light.

The National Bureau of Standards has offered grounds for locating the proposed testing machine and also has offered to assume the responsibility of supervising the actual tests. Similar offers have been received from several educational institutions but none of these offers have been definitely accepted.

In regard to the matter of handling the funds, it has been suggested that a special committee be organized to be known as the Committee on Welded Rail Joints of the American Electric Railway Association and the American Bureau of Welding. This committee would have on it, representatives from the American Electric Railway Engineering Association and its chairman or vice-chairman would approve requests for expenditures and submit the requests to the headquarters office for formal approval and disbursement of funds. Several other plans have been suggested and it is expected that a decision will be reached in the near future so that active work can be started.

# STANDARDS FOR RESISTANCE WELDING TRANSFORMERS

To the Welding Industry:

Several types of resistance welding transformers are now being sold but at the present time there is no agreement among manufacturers as to the basis of rating. Moreover, for this special class of machinery, it is essential that careful consideration be given to the viewpoint of the manufacturer, user and central station man, in order that a rating may be arrived at, which will be equitable to all. Such an attempt is made in the standards given below and we hope that it will be of use to the welding fraternity and that it will serve as a just method of comparison of the different types of machines now on the market. We realize, however, that the first issue of any such Standards is likely to be imperfect and we hope that all those interested will feel free to offer any criticisms or suggestions.

C. A. Adams, *Director, American Bureau of Welding.*

MEMBERS, RESISTANCE WELDING COMMITTEE

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# PROPOSED STANDARDS FOR RESISTANCE WELDING TRANSFORMERS

Report of Sub-Committee on Rating of Welding Machines Submitted to Main Committee on Resistance Welding of the American Bureau of Welding, April 19, 1922; including modifications made by Main Committee and subsequent modifications adopted August 1922.

## *Units in Which Rating Shall be Expressed*

The rating of a welding transformer shall be expressed as the kilovolt amperes required by the primary winding at specified frequency and specified primary applied voltage in order to perform its specified output. The output of the welder shall be given in terms of the dimensions of weld, the kind and dimensions of material which the machine can weld and the rate at which welding can be performed continuously without exceeding the temperature limit specified below. The specified applied voltage is the rated voltage.

## *Continuous Rating*

The continuous rating is the kilovolt ampere input which the machine is capable of receiving continuously without attaining a temperature rise in excess of 50° C for class A insulation and 70° C for class B insulation as measured by thermometer in temperature test.

It should be noted that in rating welding transformers, according to the temperature tests described below, heat radiation into

the transformer from the work is not allowed for by this rating. It is assumed that the heating of the transformer by direct radiation from the work can be made negligible by proper screening and location of transformer with respect to the work. Where this can not be done the temperature rise, as determined by the tests below, should be reduced by an amount corresponding to the rise in temperature produced by direct radiation from the work.

*Intermittent Rating*

As the majority of cases of welding operations are intermittent, a maximum intermittent rating for a specific duty cycle may be given and at this rating the transformer losses, Kv-a input, efficiency and power factor should be specified. The welding transformer should be capable of performing this intermittent duty without attaining a temperature rise in excess of 50°C for class A insulation and 70° C for class B insulation as measured by the thermometer in temperature test. For simple load cycles consisting of alternate maximum and zero load, where the length of the load cycle does not exceed 10 minutes, the following table may be used for finding the equivalent continuous rating for a given intermittent rating.

This table gives the intermittent rating of a transformer which has a continuous rating of 100 Kv-a for various duty cycles.

| Intermittent Rating | Duty Cycle Load off in minutes, divided by load on in minutes |
|---|---|
| 100 | 0 |
| 141 | 1 |
| 173 | 2 |
| 200 | 3 |
| 224 | 4 |
| 245 | 5 |
| 265 | 6 |
| 283 | 7 |
| 300 | 8 |
| 316 | 9 |
| 332 | 10 |

*Classification of Insulating Materials*

The Insulating Materials which have been standardized by the A.I.E.E. in Section 1004 of the 1921 Standardization Rules is here employed as follows:

*Class A.* Cotton, silk, paper and similar materials when so treated or impregnated as to increase the thermal limit, or when permanently immersed in oil; also enamelled wire. When these materials are not treated, impregnated, or immersed in oil, they are not included in Class A.

*Class B.* Mica, asbestos and other materials capable of resisting high temperature, in which any Class A material or binder is used for structural purposes only, and may be destroyed without imparing the insulation or mechanical qualities of the insulation. (The word "impair" is used in the sense of causing any change which could disqualify the insulation for continuous service).

*Rated Primary Current*

The rated primary current is the rated kilovolt amperes divided by the rated primary voltage.

*Taps*

If regulating taps are provided in the primary winding the rated primary current, rated kilovolt amperes, efficiency and heating should be based on the tap giving the highest secondary voltage.

*Method of Loading Transformers in Temperature Tests*

Whenever practicable, transformers should be tested under conditions that will give losses as nearly equal as possible to those attained under normal rated load conditions maintained long enough to permit the temperature of the winding to become constant.

(a) This may sometimes be done by connecting the secondary terminals to copper or iron tubes through which cooling water is passed or by short circuiting them through air or water cooled strips, so that a continuous output may be absorbed.

(b) Where two duplicate transformers are available the loading back method may be employed. This consists in connecting both primary and secondary windings in parallel and applying normal rated primary voltage at rated frequency. Load current is obtained by inserting sufficient voltage in the primary from an auxiliary source of power to produce the required current. On one transformer the primary current should be adjusted, so that rated input is obtained at rated voltage and frequency.

*Input Tests Under Load Conditions*

(a) Input tests under load conditions shall be made by means of suitable indicating instruments in the usual way, when the duration of weld is sufficient (about two seconds with ordinary well-damped instruments) for the instrument pointers to assume a steady position. It is preferable to connect the voltmeter and wattmeter potential circuit to the line side of the operating switch, enabling the voltage drop to be observed.

(b) When the duration of weld is so short that the instrument pointers can not assume a steady position, it is necessary to correct the instrument readings to obtain the correct values. The following method of correction is suggested: A cycle counter is connected to the operating circuit of the welder, so as to indicate the time of weld. The maximum indications of the instruments

are read and corrected by reference to characteristic curves for each individual instrument.

The characteristic curve of the ammeter is obtained by passing a known current of about 50 per cent of full scale value through the instrument for various intervals which are measured by means of the cycle counter. A curve is then plotted using as abscissae the time in cycles and as ordinates the corresponding maximum deflections expressed as fractions of the true current. The curves of the wattmeter and voltmeter are similarly obtained, the connections and method of application of current being similar to those obtaining in the welder test. The curves are used by reading the fraction of true indication corresponding to the observed time of weld and dividing the observed indication by this fraction.

This procedure is justified by the fact (established by oscillograph tests) that the current assumes its ultimate value almost instantaneously—within one or two cycles at the most.

NOTE: The characteristic curves are very nearly independent of the scale position corresponding to the steady value but if the steady values do not approximate half scale, the curves should be obtained using calibrating values approximating the test values.

### *Core Loss or No Load Loss*

This is the loss as measured by wattmeter when full rated voltage at rated frequency is applied to the primary winding with secondary circuit open.

### *Copper or Load Loss*

This is the loss as measured by wattmeter when the secondary is short circuited at its welding terminals and sufficient voltage is applied to the primary to cause full load current to flow in the primary.

### *Electrical Output*

The output in kilowatts of the welder can be obtained by subtracting from the kilowatts input the losses as determined above.

### *Efficiency*

This is obtained by dividing the maximum output in watts by the corresponding input in watts. If efficiency is expressed at less than full output the copper losses and core losses should be measured at these reduced outputs and used in calculating efficiency. If the nature of the welding requires that the voltage be reduced by a reactor or any other method not involving a change in the number of turns in the primary winding, the loss in this regulating device should be added to the copper and core losses. The power absorbed by a blower used for cooling the windings should be added to the losses.

### *Power Factor*

The maximum input in watts divided by the product of input amperes and impressed primary voltage expresses the power factor of the welder.

### *Voltage and Insulation*

It is recommended that welding transformers should not be wound for more than 550 volt circuits and should be so insulated as to withstand a test voltage of twice the rated voltage of the circuit to which the apparatus is to be connected plus 1000 volts, for one minute when hot. They should always be operated with every part other than the primary winding connected to a good ground.

*Voltage Regulation of Supply Circuit*

It is recommended that the manufacturer state the allowable variation in supply voltage from normal value; both for steady variation from normal and for momentary variation from normal.

*Name Plate*

The name plate shall specify the rated input in kilovolt amperes (continuous), rated frequency, rated primary current (continuous) and voltage. If the machine is designed for intermittent service, the maximum kilovolt amperes and duty cycle should also be given.

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# Who's Who in Welding

The American Welding Society plans in the very near future to publish a printed directory of its members, including name, address, business connection and class of membership.

If you want your name associated with welding you cannot afford to be left out.

***Write for an application blank***

## AMERICAN WELDING SOCIETY

**33 West 39th Street, New York, N. Y.**

# UNUSUAL CAST IRON CUTTING DEMONSTRATION

R. C. ROHRABACHER

As a demonstration of cast iron cutting at the plant of a large steel company, a blast furnace hearth cooling plate (10 ft. high by an average of 6 in. in thickness) was cut in less than 2½ hours. The cut was made with the plate in position.

The opportunity for the demonstration presented itself with the overhauling and remodeling of one of the steel company's large blast furnaces. In removing a salamander from the bottom of this furnace a powder blast injured one of the hearth cooling plates and it was necessary to replace it with a new one. The hearth cooling plates are made of cast iron with flanges and bolts, and with cast-in pipes for the circulation of water. Each plate constitutes an arc of a circle which is the form of the complete cooling plate assembly that surrounds the hearth. The plates are held in place not only by the bolts, but also by heavy steel bands over the plate flanges.

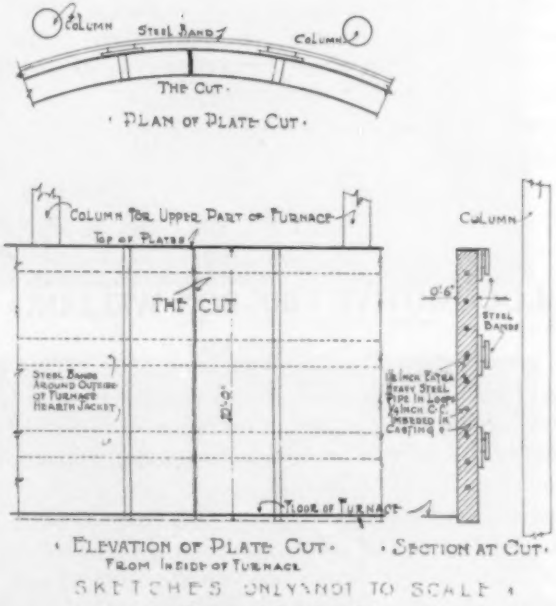


Diagram of Cast Iron Cut.

The old way of removing a damaged plate was to take away the masonary outside the hearth jacket and break up the plate with a ball and drop—a method requiring considerable labor and endangering adjoining plates. Cast iron cutting which was suggested to the steel company and then applied entirely removes the danger of doing additional damage to the good plates and facilitates the removal of the one to be replaced.

To expedite the operation, the masonary outside the hearth and near the broken plate was removed. The furnace lining and other parts above the hearth cooling plates had already been removed for other purposes. When ready to cut, the plate was exposed on the top and on both sides, there being sufficient clearance between the outer surface of the plate and the steel bands to admit of cutting the plate without damaging the bands. The cutting was done from inside the furnace. The work had to be done vertically and the cast-in water pipes presented some difficulties. Air had been blown through the pipes, but they still retained some water which ran into the kerf whenever a pipe was cut, and the open pipe ends tended to further cool down the zone of the cut by affording flues to carry off the heat.

The cut was started at the top and proceeded straight down to the bottom of the cast-iron plate, a vertical distance of 10 ft. At some points the metal was from 8 in. to 10 in. in thickness, and averaged 6 in. throughout the section, making a total of 720 sq. in. of cutting effected in two hours and 25 minutes. The cut was almost perfectly straight, being exceptionally free from even slight tacks, and the kerf, at no place exceeding ½ in. width, averaged approximately ¼ of an inch wide throughout.

The acetylene consumption was 300 cu. ft. and the oxygen consumption 1,444 cu. ft.

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## LOCOMOTIVE FIRE-BOX WELDING

J. G. GOSSMAN†

At a large copper mining plant in the Southwest some interesting oxy-acetylene locomotive fire-box welding was recently done after several unsuccessful efforts to effect the needed repairs by various other means.

A patch which had been riveted on less than a week previously had failed to hold, and the mining company was confronted with the necessity of installing a new fire-box at a cost of approximately $2,500 and with a probable delay of several months if it were found impracticable to make the repair by welding.

The story is graphically told in the illustrations. Figs. 1 and 2 show the work done on the locomotive boiler. The first shows a fire-box patch 18 ft. long by 22 in. wide, consisting of two side sheet sections and one crown sheet section. The crown sheet section of the patch was butt-welded to the old flange of the flue sheet, the old rivet holes being first filled in. The side sheet sections were

†Pacific Coast Division, Oxweld Acetylene Company.

butt-welded somewhat closer to the flue sheet knuckle, the flange having been cut off back of the old rivet holes.

The crown sheet section was welded to the crown sheet by starting in the center and welding out to each side (side of the fire-

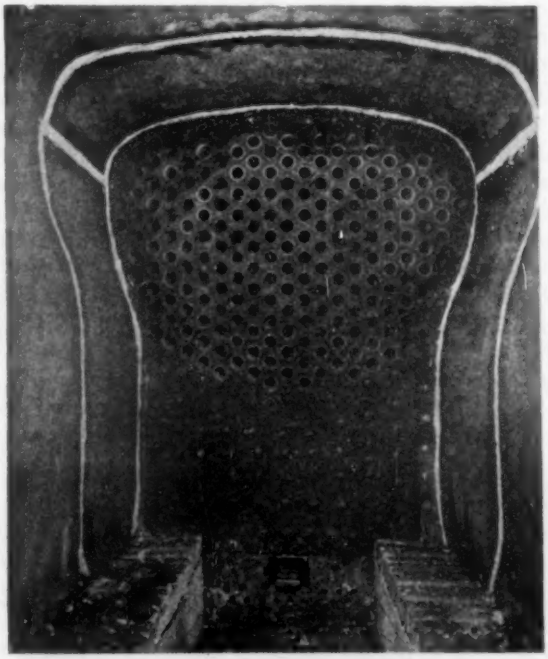

Fig. 1. Fire-Box Patch on Locomotive Boiler

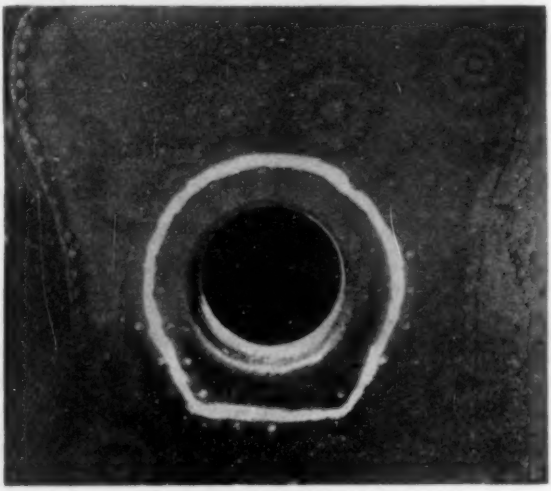

Fig. 2. Door Collar Patch Welded on Locomotive Boiler

box, end of the seam). It was then joined to the flue sheet flange with a welded seam starting 10 in. from one of the sides and extending to a point 10 in. from the opposite side. The crown sheet section was then smoothed over and reinforced from the water side.

The welds on the side sheet sections were started below the center or at the top of the flat section of the fire-box and welded down to the mud ring at the bottom, after which the upper portion of the welded seam was made. The sections were then welded to the flue sheet up to a point within about 20 in. from the top. The horizontal welds were made by finishing at the end nearest the flue sheet and the welding was completed by finishing the remaining 30 in. at the knuckle of the flue sheet on each side.

In the second picture is shown the door collar patch in the same engine. There was a total of about 15 linear ft. of welding on this patch. The total welding on the fire-box exceeded 50 linear ft.

Complete data covering the cost of this job are not available, but the locomotive was out of service only ten days, and the time saved alone was a very important consideration.

The third picture shows a ¾-in. door sheet welded into a superheater type locomotive at the same plant.

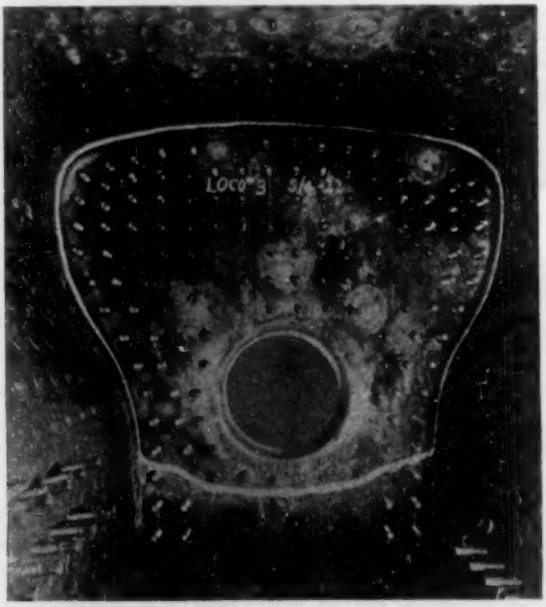

Fig. 3. Door Sheet Welded into a Superheater Type Locomotive.

This mining company has about 20 cutting and welding units, a 200-lb. duplex and a 100-lb portable acetylene generator, and supplementary shop equipment. The process is used for general work on mining and mill machinery such as pumps, rolls, flywheels,

gears, ore cars and, until recently, on manganese grates for ball mills. The company now purchases these grates already welded from an Eastern manufacturer, thereby releasing ten welders from the force ordinarily employed. The present force of welders and cutters engaged on general repair work varies from eight to ten.

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## WRITING SPECIFICATIONS FOR WELDING WIRE*

COMMANDER H. G. KNOX

The purpose of material specifications is not generally understood. Manufacturers working independently of each other produce a variety of materials. Some maintain research laboratories, some do not. Most of them keep abreast of the requirements of new arts requiring their products, a few do not. In the minds of some, quality of product is paramount, some are less careful. The result is a flood of different materials each with ingenious "talking points" and most possessing merit. In a new art this is noticeably true.

Without adequate experimental staffs, the users are often at sea as to the desirable requirements and uninformed as to what to avoid. The "practical" welder on the job, and the salesman often, are the specifications setters. Purchasing agents in general lack specific standards of quality, finish, packing, etc. One of the most useful offices of the national technical society is that of helping both users and makers.

The preparation of general specifications involves many problems which none but those who have undertaken such work realize. Primarily, specifications should be so written as to permit the utmost latitude in submitting satisfactory products and yet bar unsatisfactory materials. In most cases this inherently prevents the setting of detailed limits or tolerances and confines one to generalities. Specifications should be so drawn that inexperienced users, as well as buyers and purchasing agents, may find them a complete guide to the requirements of the consuming industries, limitation of types, sizes, packing and other details.

When the Welding Society's Wire Committee originally undertook to prepare a single set of standard specifications, the diversity of uses and the differences of opinion as to suitable welding wires made the problem a difficult one. The form of specifications also required considerable study.

It was finally decided to adopt the leaflet specifications used by the Navy Department as a guide in preparing the specifications for

*Cop'es of the Welding Wire Specifications may be obtained from the Secretary of the American Welding Society. Price to Members, 25 cents; Non-Members, 50 cents.

welding wire. This form is easily divisible into ten of fifteen paragraphs approximately as follows:

*General*

This introductory paragraph amplifies the one-line subject and adds any general explanatory clauses.

*Scope*

At the outset it was found practically impossible to embrace in a single specification all of the wire required by the varied industries of the country. A very large class of users, however, is represented by the railroads, shipyards, and generally for welding low-carbon steel. The purpose of this paragraph is to indicate where the specifications are and where they are not applicable.

*Material*

Much discussion was brought forth in the attempt to fix limits on acceptable material for welding wire. In order to avoid restriction of such steel and iron, the paragraph as finally written, defined only what materials would not be acceptable. In other cases it permitted the utmost freedom.

*Physical Properties*

Under this heading an attempt was made to exclude wires of non-homogeneous character and to guarantee to the consumer that the wires were reasonably straight and within the diameter tolerances customary to wire drawing.

*Nomenclature*

In order that specification numbers might be used by purchasing agents in ordering, each wire specification is given a number; electric arc electrodes are differentiated from gas welding rods, low carbon from alloy steels and non-ferrous from ferrous.

*Chemical Composition*

The paragraph relating to limitation of chemical analysis caused more discussion than all others. While the Committee did not at any time feel justified in setting close limits on chemical content, and did not, in any way, desire to exclude wires of commercial analysis, it was the consensus of opinion that in the interest of the welder certain limits should be set. Patented alloys also complete the subject.

*Recommended Sizes*

In order to avoid the use of gages, the Committee at first considered the designation of diameters in thousandths of an inch. Later on, however, the majority of the Society members caused the Committee to specify the wire sizes in fractions of an inch, and approximately six diameters were decided upon as representing the necessities of the average user.

*Uses*

As a guide for firms inexperienced in welding, a summary of the uses for which the respective wires are suited was included.

*Surface Finish*

The intention of this paragraph is obvious. While a coating of rust protecting material would be desirable from a storage standpoint, the many disadvantages of an oily rust-retarding coating prevents its use.

*Tests*

In nearly all of the older specifications consulted, some form of test was specified. These included microscopic examinations of the cross-section, physical tests of metal deposited from the welding wire and various other methods. Due to lack of specific information regarding such tests and to leave the specifications as broad as possible, the Committee omitted specific tests and limited their recommendation to practical demonstration of welding in all positions.

*Packing, Marking and Ordering*

While these paragraphs may seem superfluous, it is hoped they will help to standardize the methods of packing welding wire by manufacturers and that they may also serve as a guide for purchasing agents when ordering. At one time the Committee considered the addition of information showing the make-up by sizes and amounts, of an average initial order. One of the questions frequently asked by an industrial beginner in the welding game is: "What kind of wire shall I buy and how much of it?" In view, however, of the variety of industries represented, this tabulation was finally omitted.

*Coated or Covered Electrodes*

The Welding Wire Committee has long desired to include in its specifications for electrodes some definite reference to covered and coated wire. Score of analyses have been scanned and the principal foreign electrodes tested out, but there yet appeared to be no standard in sight. Moreover, the situation is further complicated by patents, as will be found in the case of other than bare electrodes.

*Gas Welding Wire*

The specifications for steel and iron rods for use in oxy-acetylene welding differ only in minor technical details from the specifications for electrodes. Certain differences of finish are specified and a larger variety of diameters are suggested.

*Non-Ferrous Welding*

Unfortunately, to date, information is limited on the non-ferrous alloys, although, generally speaking, an alloy similar in composition to the metal being welded is employed. In general, drawn wires, free from all irregularities in section, are requisite for metal electrode arc welding, while cast metals are entirely applicable to gas welding and, in some cases, where the carbon arc is used.

*Conclusion*

The Committee in charge of the preparation of welding wire specifications appreciates its responsibility and is at all times looking for suggestions tending to simplify the specifications and make them of 100% practical use both to the user and manufacturer. As stated at the outset, the object of these specifications is to include in a practical standardized form such essential information as will permit purchasing agents to order, without chance of misunderstanding, a material of the highest quality for the welding operation involved and, at the same time, accord with the manufacturers' standards. Only the first steps in this direction have been taken and it is the urgent plea of the Welding Wire Committee that everyone use these specifications and where they are lacking or incorrect that constructive suggestions be submitted to the end that the specifications in their final form may be the standard of the welding world.

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**EMBLEM**

All members of the Society are privileged to wear the Society emblem. Emblems may be obtained in two styles from the Secretary's office. Price, gold-filled, 75c., 14-K. gold, $5.00.

# CURRENT WELDING LITERATURE

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# The American Welding Society

The American Welding Society is organized to provide united and co-operative action in extending the knowledge of the art of welding and its field of industrial application. The field for further application of welding is enormous, and progress in it is being delayed only by incomplete knowledge and by the confusing and opposing claims of competing interests.

The Society acts as a clearing house for information. Through papers and monthly meetings of local sections of the Society an opportunity is created for the individual manufacturer, engineer, plant superintendent, foreman, operator, etc., to contribute his own knowledge in welding and at the same time receive the benefit of the combined knowledge and experience of all other members of the Society. Special publications in addition to the regular monthly proceedings are issued from time to time giving results of researches, standardization work and other information of value to the members.

## CLASSES OF MEMBERSHIP

Extracts From By-Laws

### ARTICLE I

Section 1. Individuals having received the approval of a majority of the Membership Committee shall become members of this Society upon the payment of dues, except in the case of honorary members who shall be elected by unanimous vote of the full Board of Directors.

Section 2. Membership shall be divided into five classes:

Class A. Sustaining members, being individuals or individuals delegated by corporations, firms, partnerships, etc., interested in the science and art of welding, with full rights of membership. Annual dues ..... $100.00

Class B. Members, being individuals interested in the science and art of welding, with full rights of membership.

Engineers or individuals competent by experience or training to plan or direct welding operations are eligible to this class. Annual dues ..... $20.00

Class C. Associate members with right to vote but *not* to hold office, except in Sections as may be provided for by the By-Laws of the Sections. Supervising welders, inspectors and skilled operators, with three or more years' practical experience in welding are also eligible to this class. Annual dues ..... $10.00

Class D. Operating members, who are welders or cutters by occupation, without the right to vote or hold office except in Sections as may be provided for by the By-Laws of the Sections. Annual dues ..... $5.00

Write to the Secretary for a membership blank.

# Technical Bulletins

These Bulletins are published under the auspices of the American Bureau of Welding. The Bureau is a joint advisory board of the American Welding Society and the Division of Engineering of the National Research Council on welding research and standardization. It acts as the Research Department of the Society.

BULLETIN No. I

## Standards for Testing Welds

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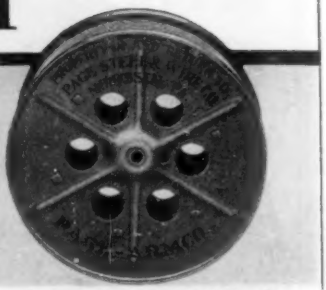

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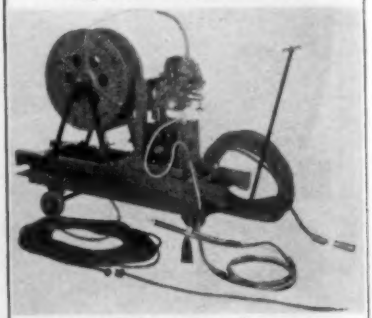

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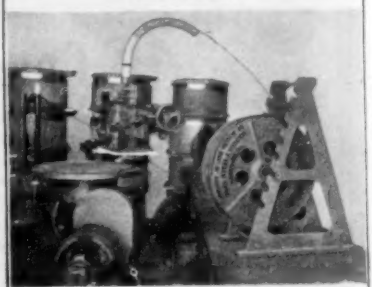

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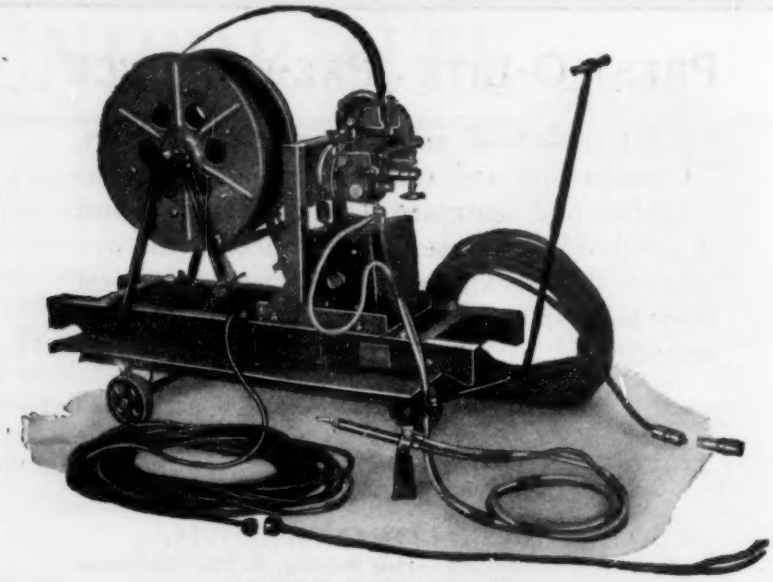

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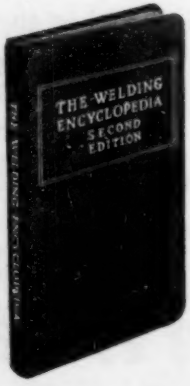


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